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AFS

JANUARY, 1960

Golf & Wolf Rds., Des Plaines, Ill.

modern castings

■ Lynchburg Foundry Co. considers money spent on training employees as one of its best investments. These two apprentices are participating in the extensive Lynchburg Training Program described on page 44.

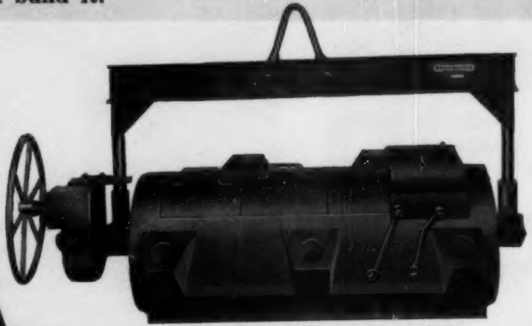
Circle No. 145, Page 123

LADLES UNLIMITED

Wherever metal is treated, inoculated, distributed or poured — MECHANICALLY — the chances are good that the ladle equipment is MODERN! Ladles in all types and sizes are engineered to the metal loads and pouring conditions. There are no size limitations: You name it! We'll build it!

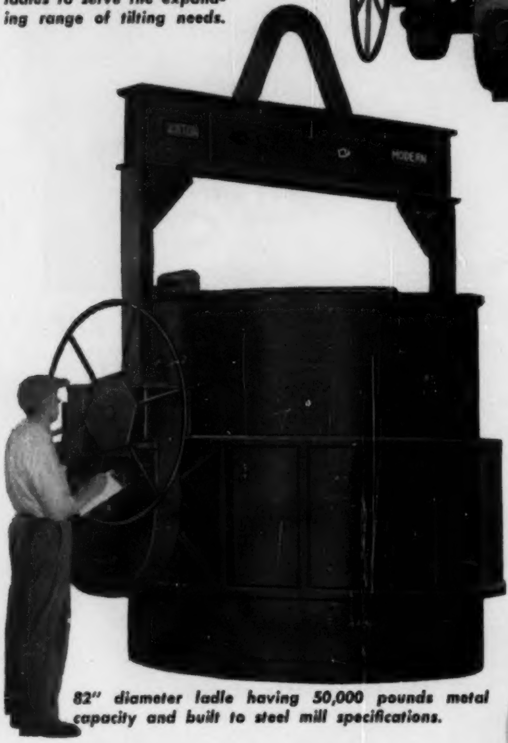
800 pound, straight-sided ladle with square bail and gearing. Seven standard gear sizes are available for ladles to serve the expanding range of tilting needs.

Modern 17½" top diameter, tapered, covered ladle with No. 1 type shank, roller bearing trunnions and detachable bail.

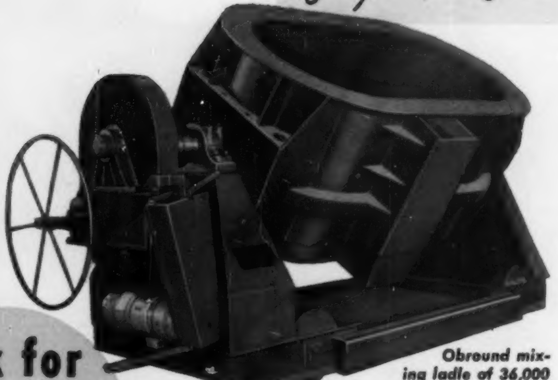


A five-spout ladle, designed to hold 1500 pounds, pours from either side.

Pete—
I believe we should order a couple new ladles now! See me!
B.R.

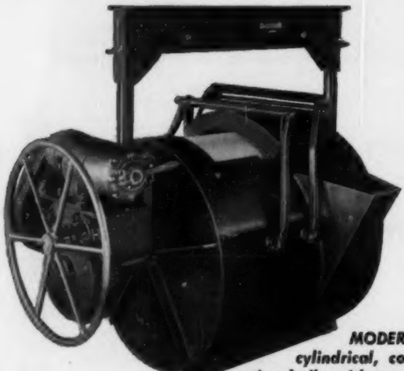


82" diameter ladle having 50,000 pounds metal capacity and built to steel mill specifications.



Obround mixing ladle of 36,000 pounds metal capacity.

Ask for CATALOG P-152-A



MODERN 2000 pound cylindrical, covered, distributing ladle with special bail. Tilted by motor or hand wheel.

Special inoculation ladle on transfer car. Ladle bowl is detachable.

MODERN

Dept. MC-1

MODERN EQUIPMENT COMPANY

PORT WASHINGTON, WISCONSIN

Circle No. 147, Page 123

modern castings

the technical magazine of the metalcasting industry

january, 1960
vol. 37, no. 1

[redacted]

features

featurettes

news of the industry

materials and equipment

departments

future meetings and exhibits

Jan. 11-15 . . Society of Automotive Engineers, Annual Meeting. Statler and Sheraton-Cadillac Hotels, Detroit.

Jan. 15 . . Malleable Founders Society, Semi-Annual Meeting. Hotel Sheraton-Cleveland, Cleveland.

Jan. 25-28 . . Plant Maintenance & Engineering Show. Convention Hall, Philadelphia.

Feb. 1-5 . . American Society for Testing Materials, Committee Week. Hotel Sherman, Chicago.

Feb. 3-4 . . Illinois Institute of Technology, Armour Research Foundation and American Welding Society, Midwest Welding Conference. Technology Center, Chicago.

Feb. 11-12 . . AFS Wisconsin Regional Foundry Conference. Hotel Schroeder, Milwaukee.

Feb. 14-18 . . American Institute of Mining, Metallurgical & Petroleum Engineers, Annual Meeting. New York.

Feb. 17-18 . . Malleable Founders Society, Technical & Operating Conference. Wade Park Manor, Cleveland.

Feb. 18-19 . . AFS Southeastern Regional Foundry Conference. Hotel Thomas Jefferson, Birmingham, Ala.

March 7-8 . . Steel Founders' Society of America, Annual Meeting. Drake Hotel, Chicago.

March 14-18 . . National Association of Corrosion Engineers, Annual Conference. Dallas, Texas.

March 16-17 . . Foundry Educational Foundation, Annual College-Industry Conference. Statler-Hilton, Cleveland.

April 4-6 . . American Institute of Mining, Metallurgical & Petroleum Engineers, National Open Hearth Steel Conference and Blast Furnace, Coke Oven and Raw Materials Conference. Palmer House, Chicago.

April 13-14 . . Malleable Founders Society, Market Development Conference. Edgewater Beach Hotel, Chicago.

April 21-28 . . American Society of Tool Engineers, Annual Meeting & Tool Show. Artillery Armory and Sheraton-Cadillac Hotel, Detroit.

April 24-28 . . American Ceramic Society, Annual Meeting. Bellevue-Stratford Hotel, Philadelphia.

April 25-29 . . American Welding Society, Annual Convention. Biltmore Hotel, Los Angeles.

April 26-29 . . National Industrial Sand Association, Annual Meeting. Key Biscayne, Fla.

May 3-5 . . Iron and Steel Institute, Annual Meeting. London, England.

May 9-13 . . AFS 64th Annual Castings Congress & Exposition. Convention Hall, Philadelphia.

May 25-26 . . American Iron and Steel Institute, General Meeting. Waldorf-Astoria Hotel, New York.

June 6-8 . . Malleable Founders Society, Annual Meeting. Elbow Beach Surf Club, Hamilton, Bermuda.

June 16-17 . . AFS Chapter Officers Conference. AFS Headquarters, Des Plaines, Ill. and LaSalle Hotel, Chicago.

June 26-July 1 . . American Society for Testing Materials, Annual Meeting & Exhibit. Chalfonte-Haddon Hall, Atlantic City, N. J.

Sept. 19-24 . . International Foundry Congress. Zurich, Switzerland.

Sept. 22-23 . . National Foundry Association, Annual Meeting. Edgewater Beach Hotel, Chicago.

Oct. 12-14 . . Gray Iron Founders' Society, Annual Meeting. Netherland-Hilton Hotel, Cincinnati.

Oct. 13-15 . . Non-Ferrous Founders' Society, Annual Meeting. Grove Park Inn, Asheville, N.C.

Oct. 17-21 . . American Society for Metals, Annual Meeting and Metal Exposition & Congress, Trade & Convention Center, Philadelphia.

Nov. 14-16 . . Steel Founders' Society of America, Technical & Operating Conference. Carter Hotel, Cleveland.

Nov. 27-Dec. 2 . . American Society of Mechanical Engineers, Annual Meeting. Statler Hotel, New York.

AFS Chapter meetings for January appear on page 119.

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Circle No. 149, Page 123

Have you read?

A Visit With 500 Die-Cast Plants . . . Kennedy, W. C. . . . 600 pp. American Charcoal Co., Detroit. 1959. Comprehensive manual containing over 250 illustrations, 100 chapters and 37 data tables on the subject of die casting.

Extractive Metallurgy . . . Newton, Joseph . . . 532 pp. John Wiley & Sons, Inc., 440 Fourth Ave., New York. 1959. Written primarily as a text for a first course in extractive metallurgy, this book presents the subject through the unit process method. Author discusses basic principles rather than detailed practices. Includes such topics as metal crystals, equilibrium diagrams and Gibbs' phase rule.

Selected Methods of Analysis of Foundry Materials . . . Part 1, Pig Iron and Cast Iron . . . 97 pp. The British Cast Iron Research Association, Alvechurch, Birmingham, England. 1959. This is a laboratory manual of selected methods of chemical analysis in simple and inexpensive form. Subject matter has been restricted to the practical details of each method. Laboratory equipment and techniques are covered in appendices.

Foundry Engineering . . . Taylor, H. F., Flemings, M. C. and Wulff, J. . . . 407 pp. John Wiley & Sons, Inc., 440 Fourth Ave., New York. 1959. Book presents a comprehensive, modern, scientific approach to engineering principles and methods of foundry operation. Particularly outstanding are the treatments of solidification and structure of cast metals and principles of gating and risering. Also covers refractories, casting processes, melting equipment and processes, sand reclamation and control, welding and heat treatment.

Statistical Abstract of the United States, 1959 . . . U.S. Dept. of Commerce, Bureau of the Census . . . 1042 pp. U.S. Government Printing Office, Washington 25, D. C. Latest national statistics on social, political and economic activities in the United States. Includes useful data on foundry industry for years 1954-1958.

The Engineering Index—1958 . . . Engineering Index, Inc., 29 West 39th St., New York. 1959.

The annotated reference items published in this volume provide a comprehensive digest of important information on technical, scientific and economic problems as recorded last year in engineering magazines, special bulletins and government reports gathered from all over the world.

Lindberg-Designed

furnaces, more than 75 of them, help Ford Motor Company maintain casting production and quality standards

Handsome entrance to new plant of Ford Motor Company, Sheffield, Alabama.

Metal temperatures are positively controlled through Lindberg Control Panel.

Some furnaces are arranged for hand ladling and others are equipped with Lindberg Autoladle.

The new Aluminum Castings Plant of Ford Motor Company, Engine and Foundry Division, at Sheffield, Alabama, is a model of modern production efficiency. Contributing to its effective operation is a huge battery of Lindberg-Fisher aluminum holding furnaces, more than 75 of them. Eight large 65,000 lb. capacity reverberatory holding furnaces receive molten aluminum delivered from an adjacent Reynolds Metals plant and hold it at the desired temperature. Six other reverberatory furnaces, each with 20,000 lb. capacity, are used for remelting scrap aluminum from trimmed parts and holding metal at its usable temperatures. Molten metal is then delivered to more than 60 electric resistance holding furnaces in the casting area as needed. This unique installation, developed by Ford engineers in conjunction with Lindberg, is a major factor in maintaining the high quality product and production standards required by Ford.

Lindberg equipment and Lindberg planning can help you find the most effective answer to any problem of applying heat to industry. We cover the field, melting and holding, heat treating, tempering, brazing, enameling furnaces, ceramic kilns, high frequency units, and are in the ideal position to recommend just the type of equipment most suitable for your needs. This can be factory built or field-installed in your own plant, fuel-fired or electric. Consult your local Lindberg Field Representative (see the classified phone book) or get in touch with us direct. Lindberg-Fisher Division, Lindberg Engineering Company, 2440 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.

Molten aluminum is delivered direct to reverberatory holding furnaces.

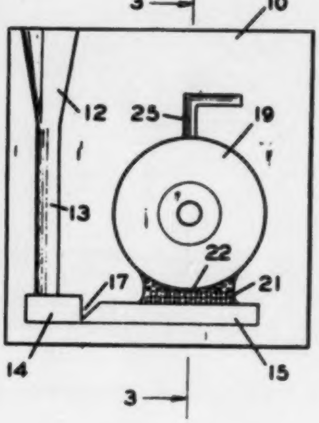
The molten metal is held in these 14 huge furnaces for distribution to the casting areas.

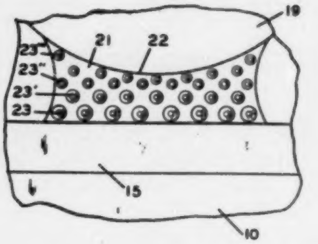
LINDBERG heat for industry

Circle No. 151, Page 123

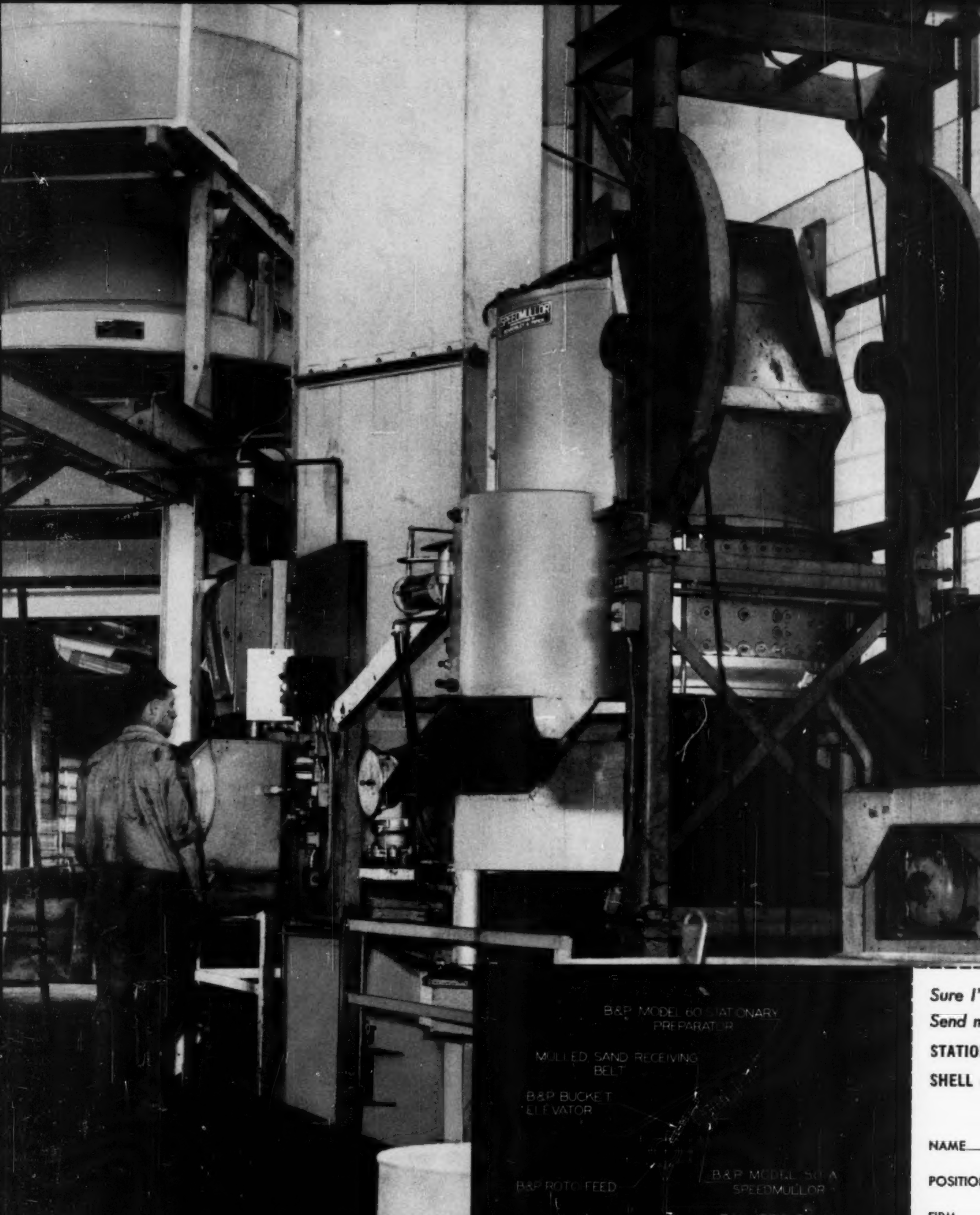
Patented Gating System

This invention covers a patented technique for absorbing gases and inclusions from molten metal in the gating system of a resin-sand shell type mold. Cleaning action is afforded by a number of teeth-like truncated cone projections (21) along the walls of ingate. These teeth are gas-absorbent aggregates molded integrally with the mold halves. The maze of cones catch slag impurities and reduce velocity of the metal entering the mold.





The two diagrams are views of a shell mold demonstrating the patented principle. Molten metal flows down through the sprue (12,13), to the reservoir (14), through the restriction (17) and into the runner (15). Metal then rises up through the maze of cones (21,23) where it is cleaned before entering the mold cavity (19). The lower diagram is an enlarged view showing the distribution of the cones in the ingate. Pat. No. 2,788,554 issued to Charles C. Phipps and assigned to E. N. Harrison, Chattanooga, Tenn.



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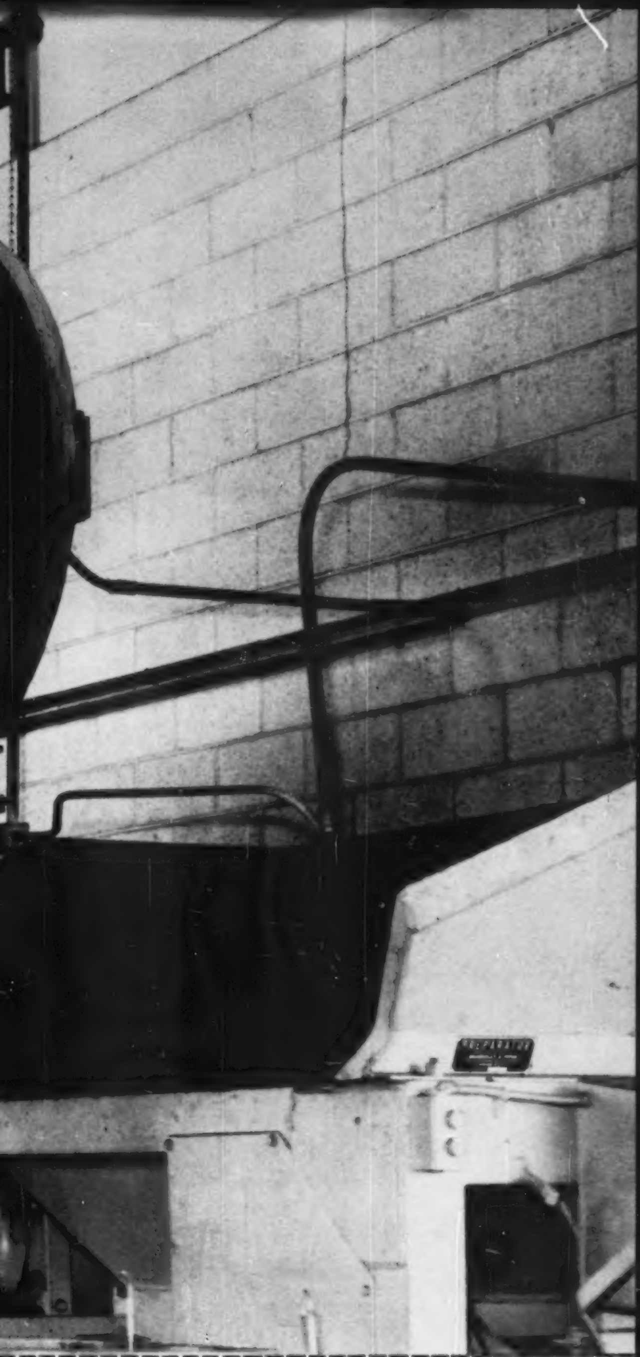

Have a Skill Problem?

From B & P Research . . .

BUILT-IN SKILL

Small Nekoosa Foundry* had a *serious problem.* A chronic skill shortage aggravated production problems . . . made quality control difficult. Costs were high, and getting higher. But there was a *solution!*

Nekoosa installed a Speedmullor-Preparator Unit

- because fast, thorough Speedmullor-Preparator Units provide precise control of all mulling variables without highly skilled operators.
- because rugged Speedmullor-Preparator Units provide more years of low maintenance operation.
- because economical Speedmullor-Preparator Units provide the most productive capacity at the lowest operating cost.
- because more sand is prepared in Speedmullor-Preparator Units than all other units combined.

They installed a Sandslinger

- because Sandslingers have "built-in skill" to handle the widest variety of jobs.
- because Sandslingers offer maximum flexibility.
- because Sandslingers cost less to install . . . less to maintain . . . use existing patterns and flasks.
- because Sandslingers are efficient . . . no penalty for capacity.

And here are the results:

- A serious skill shortage solved.
- Molding time cut by as much as 60%.
- Casting quality improved.
- Competitive position improved.

*Nekoosa Foundry and Machine Works, Inc.
Nekoosa, Wisconsin

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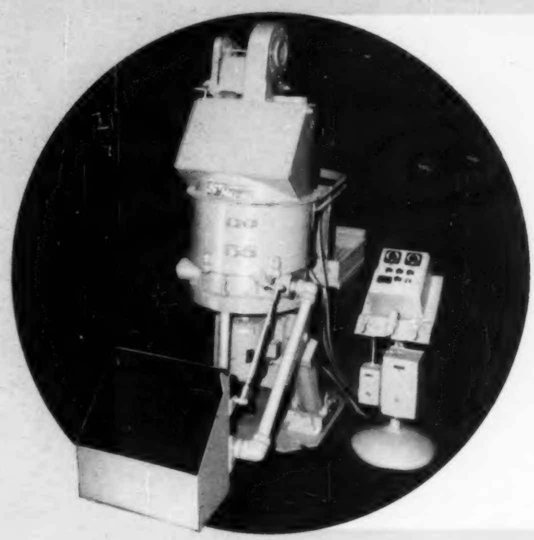
LOOK AT THESE "BUILT-IN SKILL" DEVELO



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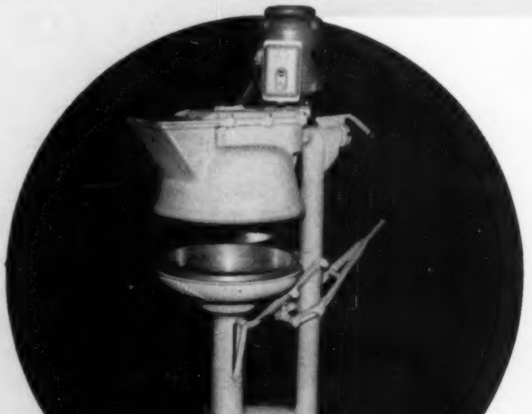
Increase Core Production with Available Skill!

Anyone can draw complex cores with the Vibra-Draw. Team it with the Flexiblo and you can produce hard-to-make jobbing cores on a real production basis with relatively *unskilled manpower.*

Machined grooves in the draw head and an air vibrator make every draw accurate regardless of core box draft or height of draw. The ruggedly built Vibra-Draw will provide years of trouble-free service.



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◀ USE THIS CARD TO LEARN ABOUT YOU

ELOPMENTS BY BEARDSLEY & PIPER

ow Cost Shell Sand Unit!

get-minded foundries cut shell sand costs in large
mall shell-process departments with the Shell Mull-All.
re is plenty of capacity to keep several high-speed shell
making units in full, profitable operation.

low-cost unit provides up to 4,500 lbs. of shell
l per hour with the preheat process . . . up to 3,000 lbs.
hour using the cold process.

Shell Mull-All is a complete ready-to-operate package
skip-bucket loading device, cooling and conveying
en and Mulltrol automatic control unit.

er low-cost Mull-All models are available for molding,
ng and core sand application, too.

ew Low Cost Lab Unit
nproves Sand Control

plow design, scientifically contoured mulling bowl,
rubber-tired mulling wheels assure thoroughly
ed sand batches which very closely duplicate molding
core sand mixtures prepared by production
dmullors. The Lab Mulbaro provides close laboratory
rol of sand preparation and permits practical,
cost experimentation with the many new binders.
trol is available for batch after batch uniformity
ugh precise control of the mulling cycle. Lab Mulbaros
kly pay for themselves through improved sand
rol, improved sand properties and the ensuing
ovement in casting quality.

YOUR STAKE IN B & P RESEARCH

L. C. Gleason

V. M. Rowell

F. Harness

G. W. Anselman

J. C. Cleeves

W. L. Hartley

let's get personal

Lawrence C. Gleason . . . president of Gleason Works, Rochester, N. Y. since 1958 has been elected as president and general manager. Gleason, grandson of William Gleason, founder of the company, joined Gleason Works in 1933, became foundry superintendent in 1946, a director in 1947, vice-president in 1955 and president in 1958. **Howard F. Carver**, who has served as vice-president, was elected vice-president and assistant general manager. Carver joined Gleason Works in 1934, became a director in 1953 and vice-president in 1955.

Victor M. Rowell . . . formerly executive vice-president, Harry W. Dietert Co., Detroit, is now new product manager, Federal Foundry Supply Div., Archer-Daniels-Midland Co., Cleveland.

Frank J. Gentile . . . has been named chief engineer, Youngstown Foundry & Machine Co., Youngstown, Ohio. He is succeeded as assistant chief engineer by **Joseph A. Becker**, formerly of Aetna Standard. **Anthony P. Sgambati**, formerly with Lombard Corp., was named project engineer.

Halle P. Robb . . . has been named as manager of sales for all Electric Steel Foundry Co., Portland, Ore., products in northern California, Nevada and Utah. **W. R. Rice** has been named manager of sales, mill products, in the area for stainless steel and plastic materials and products for which ESCO is a distributor. **Don Erickson**, sales representative, returns as office manager of ESCO-San Francisco. **Karl Moore**, who served as interim offce manager, becomes a sales representative.

Frank Harness . . . is now chief metallurgist, Ductile Iron Foundry, Inc., Stratford, Conn. For the past several years Harness was chief metallurgist, Gardner-Denver Co., Quincy, Ill.

George W. Anselman . . . of Anselman Foundry Services, St. Charles, Ill., has been appointed sales agent in the Chicago area for ABC foundry coke, produced by Alabama By-Products Corp., Birmingham, Ala. Anselman, formerly president of Whirl-Air-Flow Corp., started his consulting service in 1957.

John C. Cleeves . . . recently of Manchester, England, is now development engineer, Dust Control Div., Pangborn Corp., Hagerstown, Md. He was formerly associated with Tilghmans Ltd., Prat-Daniel, Ltd. and Sturtevant Engineering Co., Ltd.

William L. Hartley . . . after 44 years of service with Link-Belt Co. has retired at the age of 65. Hartley started with Link-Belt in 1915 as a draftsman, later entering sales. At his retirement he was engineer, executive sales, at the company headquarters, Chicago.

Cameron Sevier, Jr. . . . has been appointed a sales and service engineer with Basic, Inc., Cleveland. Seiver will be headquartered in the Atlantic district office covering the New England territory as well as the Atlantic seaboard and southeastern states. He was formerly assistant superintendent, open hearth and electric furnaces, Republic Steel Corp., Gadsden, Ala.

C. Seiver

W. A. Stengl

Walter A. Stengl . . . has been named plant manager, Castalloy Co., Natick, Mass. Previously he had been chief metallurgist and superintendent, Raleigh Mfg. Co., Philadelphia.

Robert C. Harris . . . is now supervisory metallurgist, Beryllium Corp., Reading, Pa. He was formerly chief research and development engineer, Arwood Precision Casting Corp., Tilton, N. H.

L. A. Harrison . . . has been appointed general sales manager and **P. A. Gaebe** assistant general sales manager of the eastern division of Kaiser Refractories & Chemicals with headquarters in Pittsburgh, Pa. Harrison has been serving as assistant sales manager of Mexico Refractories Co., Mexico, Mo., since 1955. Gaebe was formerly eastern regional sales manager for the Kaiser Chemicals Div. **Jack T. Putnam** has been named general sales manager of the western division of Kaiser Refractories & Chemicals. He will continue to make his headquarters at Oakland, Calif., where he has been serving as western regional sales manager. **H. F. Randolph** has been appointed general sales manager and **Robert L. Peterson** assistant general sales manager of the central division of Kaiser Refractories & Chemicals. Both will make their headquarters at Mexico, Mo. Randolph has been serving as office manager of Mexico Refractories Co., Mexico, Mo. and Petersen has been central regional sales manager for Kaiser Chemicals.

W. Joseph Cluff . . . has retired as president, Frederic B. Stevens, Inc., Detroit and will continue as a consultant to Stevens and as a member of the board of directors, Udylite, Corp., Detroit. Cluff is succeeded by Clyde H. Reeme, president of the Udylite Corp., of which Stevens is a subsidiary.

Richard C. Trushel . . Ohio Ferro-Alloys Corp., Canton, Ohio, has been transferred from the Canton territory to the St. Louis territory.

C. W. Yaw . . . past chairman of the AFS Detroit Chapter has been transferred from assistant superintendent of the foundry division to assistant superintendent of the machining and heat treat division, Cadillac Motor Car Div., GMC. **K. W. Simerly**, formerly foreman of the cleaning room in the foundry division has replaced Yaw.

L. T. Crosby . . . has formed his own company, Crosby Foundry Sales, Rocky River, Ohio. He has been associated for 19 years with Sterling National Industries.

William H. Schweikert . . . is now technical director, Castparts Corp., Portland, Ore. He was formerly with General Electric Co. for nine years in the Aircraft Gas Turbine Div., Cincinnati.

John G. McLain . . . has been named western manager of foundry and ma-

Continued on page 18

Circle No. 134, Page 123

FROM TOM BARLOW

News for nonferrous: In molding sands . . . the wetter the better!

It's nice to make castings better. It's nice to make castings cheaper. But it's *news* when you make them better and cheaper at the same time.

We've spoken here frequently of the unusual success resulting from using Plasti-Bond as an additive to both synthetic and natural sand to make good grey iron and malleable castings. The flowability of a Plasti-Bond sand together with its tendency to reduce buckles, scabs and veins has been a major item. This had to do with appearance.

In addition, however, the flowability imparted by Plasti-Bond permits a reduction in overall casting size which can contribute substantial savings. If we extend this same thinking to brass, bronze and aluminum with higher cost per pound of raw materials, the savings by dimensional control become startling.

Although high-pressure molding was developed originally for grey iron, we now find that about half of our applications are in the nonferrous field. The success here is related partly to the fact that these high-flowability sands, both natural and synthetic, provide the foundrymen with real savings by reducing casting weights from 2% to 5%. At the same time, we've learned to modify the practice to produce truly out-of-this-world finish on these nonferrous castings. The technique — or the change in the technique — that was evolved from the grey iron and malleable practice is either confusing or amusing or both.

Plasti-Bond sands were originally developed to reduce moisture contents. As a matter of fact, it is possible (although not recommended) to operate these sands *without* moisture. As we developed experience in nonferrous, however, we found that low-moisture sands, like the zero-moisture sands, had a tendency to develop epidemics of dirt holes.

Success was obtained when we reversed the cycle and used the Plasti-Bond not to reduce the moisture but to permit operation at higher moistures. We raised the bentonite levels and came up with strengths which would scare most brass men to death. However, these rather high-strength green sands with moistures of 4% or more had the flowability to provide truly outstanding surface appearance — and at the same time, gave the resistance to drying out and to dirt formation that was required.

It seems that in the nonferrous practice, then, the desire is not to eliminate moisture in the molding sand but to learn to live with it

successfully. When this is done, there are certain distinct advantages to the high-moisture level. The Plasti-Bond gives the flowability and the finish while the high moisture combined with somewhat higher clay gives the durability, versatility and freedom from casting defects.

It is no news that the brass and bronze people (and to a certain extent the aluminum people) are plagued with veining. Overnight elimination of this problem with Plasti-Bond has led to its wide acceptance, particularly in castings subject to this trouble. Some of the outstanding success has been in castings which tend to show ram-offs (occasionally described as shifts). Round castings such as valves, fittings, etc., are outstanding examples of this truly new approach to successful nonferrous founding.

let's get personal

Continued from page 14

chinery sales for Blaw-Knox Co. He joined the company in 1946.

Stan Brand . . . formerly sales manager, Snyder Foundry Supply Co., is now general manager, Multi-Metals Co., Los Angeles.

Geoffrey Paget . . . has been named chief metallurgist, Shaw Process Development Corp., Port Washington, N. Y.

John E. Grimshaw . . . has been named plant superintendent, Union Die Casting Co., Whittier, Calif. He will supervise production of three divisions: custom die casting, consumer products and plumbing and hardware.

John J. Mueller II . . . has been appointed director of advertising for the Enterprise Div., General Metals Corp. and Enterprise Engine & Machinery Co., General Metals sales subsidiary. Mueller will also direct advertising of the Foundry & Forge Div., from San Francisco.

Bernard J. Alperin . . . has been named manager-product engineering, for Everett Foundries of General Electric Corp. Previously he had been supervisor of inspection in the Everett Foundries.

Hartley S. Ball . . . is now president, City Pattern Foundry & Machine Co., Detroit. He has been with the company 12 years, latterly as vice-president of sales.

Henry Swigert . . . is district sales representative in Arizona and New Mexico for Electric Steel Foundry Co. with headquarters in Phoenix, Ariz.

J. Paul Maddox . . . is now manager, Specialties Div., North American Refractories Co., Cleveland. Maddox, formerly with Mexico Refractories Co., will direct all specialty sales from Cleveland.

Carl Decina . . . is now plant superintendent, Rolle Mfg. Co., Lansdale, Pa. He was formerly plant superintendent for Superior Bearing Co., Buffalo, N. Y.

David D. Hunsaker . . . has been named manager, sales development, Frank G. Hough Co., Libertyville, Ill. He has been with Hough Co. for 14 years and was formerly a district manager.

Hugh Lowry . . . has been named as sales representative, Memphis territory for A. P. Green Fire Brick Co., Mexico, Mo. He was formerly sales representative for Illinois A. P. Green Fire Brick Co., a Chicago affiliate.

Charles J. Bergen . . . has been named manager, sales administration, Metals

Continued on page 20

let's get personal

Continued from page 18

Div., Kelsey-Hayes Co., New Hartford, N. Y. Other appointments in the market and product expansion program of the division are: **Patrick W. Nolan,** manager, marketing planning; **Richard S. Spencer,** eastern sales manager. Bergen was with the American Car & Foundry Div., ACF Industries, Inc., New York, before joining the Metals Division in 1959. Nolan was associated with ALCO Products, Inc., Schenectady, N. Y., prior to joining the Metals Division in 1959. Spencer was formerly with Metals Processing Div., Curtiss-Wright Corp., Buffalo, N. Y., before joining the division in 1957.

obituaries

Garnet P. Phillips, 57, AFS National Director 1956-1959, and general supervisor, foundry research, International Harvester Co., Chicago, died Nov. 29. Phillips became chief chemist for Frank Foundries Corp., Moline, Ill., in 1926 and from 1927 to 1935 was at Frank Foundries, Davenport, Iowa. He started his association with International Harvester Co. in 1935, progressing to general supervisor, foundry research in 1946. He was chairman of the AFS Chicago Chapter 1940-41. Phillips was active in technical affairs of AFS as well as the American Society for Metals, American Society for Testing Materials and Society of Automotive Engineers. Among the AFS Committees on which he served were Editorial Committee on The Cupola and Its Operation, Advisory Committee of the Gray Iron Division, Cupola Advisory Committee, and Air Pollution Control Committee.

G. P. Phillips

Henning B. Dieter, 61, founder of the D & H Foundry, Austin, Texas, died Nov. 3, following a long illness.

William J. Hutchinson, 75, a director and former treasurer of the International Nickel Co. of Canada, Ltd., and its United States subsidiary, International Nickel Co., died Nov. 25 in New York after an illness of several months.

Frederick B. Clark 70, a director of Whitehead Bros Co. since 1944 died Nov. 20. He had been associated with Whitehead Bros. for 41 years, starting as a salesman, was New England manager for the past 16 years. Clarke was a resident of Cranston, R.I.

HOLLYWOOD HAS *Brigitte Bardot....*

Labor has Hoffa. Dodgers have the pennant. The Republicans have Nixon and the Democrats have Kennedy . . . but, only a foundryman can have Handlebar Harry: In fact, *YOU* may have Handlebar Harry!

If you do, you have the oldest Simpson Mixer still in foundry operation, and it may win you a trip to Hawaii. But remember . . .

Any Mix-Muller can win a prize

All Mix-Muller users are eligible for a prize no matter how new the machine.

This $5000 contest search marks the inauguration of National's Mix-Muller Retirement Plan—a program designed to make it easier and more economical for Mix-Muller users to meet the production challenge of the 60's with a modern, high production F Series Mix-Muller.

Why not return your entry today? Entry blank, rules and full contest details are attached.

See the next page for prizes and rules

HANDLEBAR HARRY CONTEST

OFFICIAL ENTRY BLANK

Be sure to fill in the 50-word statement below.

1. I have read and agree to the contest rules. Here is my entry. The serial number of our *Handlebar Harry is* ______________.

(If more than one mixer, enter oldest number only.) If no record of serial number, contact your National Agent.

2. This Simpson Mixer is in regular operation in our foundry and has been the property of our company for _____ years.

Your Name________________________________

Your Company____________________________

Address__________________________________

City________________**Zone**____**State**__________

Entry must be postmarked no later than midnight, February 28, 1960.

50-Word Statement

In 50 words or less, tell how this Simpson Mix-Muller has contributed to the success of your foundry operation: Example: **This Mix-Muller has served our foundry daily for _______ years without downtime for repairs. In that time, it has prepared _______ tons of sand.**

(type or print below . . . or attach a separate sheet)

M

F

DM

TEAR OFF and return to

HANDLEBAR HARRY
National Engineering Co.,
Machinery Hall, Chicago 6, Illinois

Build an idea file for improvement and profit. Circle numbers on literature request card, page 123 for more information about these . . .

new products and processes

HEAVY-DUTY BLAST CLEANING BARREL . . . cleans castings weighing up to 500 lb and handles batch load of 2700 lb. The 15-cu-ft barrel delivers 50,000 lb of abrasive hourly. Cleaning and recycling consists of four phases: coarse screening; separation and selection in scalping drum; removal of sand and fine abrasive particles in air-wash

separator; final screening. Clean, usable abrasive then goes to storage hopper for re-use. Slat-type work conveyor is virtually jam proof. In event of jamming, while either blasting or unloading, automatic torque arm disengages reducer drive and stops work conveyor until work is cleared and torque arm manually engaged. Pangborn Corp.

For More Information, Circle No. 1, Page 123

TENSILE TESTER . . . portable unit performs standard tensile and compression tests. Machines available in two sizes: 5000 to 20,000 lb capacity or 20,000 to 40,000 lb capacity. Steel City Testing Machines, Inc.

For More Information, Circle No. 2, Page 123

PLUNGING LADLES . . . for use in new ductile iron technique comes complete with loose covers. Ladles available in eight capacities from 1000 to 6000 lb. Industrial Equipment Co.

For More Information, Circle No. 3, Page 123

PREFABRICATED STORAGE RACKS . . . assembled without cutting, welding or use of tools. Rapid assembly and reuseability made possible by locking connectors. Upright trusses available in heights of 6-20 ft and in depths of 2-6 ft. Adjustable load beams available in widths of many sizes and may be installed at any point along entire height of upright truss. Storage Products Corp.

For More Information, Circle No. 4, Page 123

CUT HYDRAULIC MAINTENANCE COSTS . . . with kit sets adaptable to all types of machines for removing and installing gears, bearings, bearing cups, wheels, sheaves, shafts, couplings, sprockets and pulleys. Sets include ram, pump, puller and appropriate attachments. Owatonna Tool Co.

For More Information, Circle No. 5, Page 123

SAFETY TROLLEY SYSTEM . . . eliminates hazard of exposed crane trolley wires by covering all live parts and preventing accidental contact. Trolley wire is covered by special rubber duct with self-closing slot through which trolley shoe passes. Arms supporting the contact shoes are dead, current being carried by insulated jumpers. Continuous lengths of flexible duct permit straight or curved runs without limitation. Installation requires no plant shutdown. Northbrook Products, Inc.

For More Information, Circle No. 6, Page 123

THERMOCOUPLE WIRE . . . designed for use where high temperature, size and adaptability are prime factors. Wire is magnesium oxide-packed, metal sheathed construction. Complete thermocouples available with integral, insulated or exposed junctions, together with head and block or quick connect plugs. Pyrometer Co. of America.

For More Information, Circle No. 7, Page 123

CRANE SCALE . . . suitable for use under extreme conditions is available in capacities of 1000 to 20,000 lb. Producer claims minimum size, reduced weight, maximum accuracy. Martin-Decker Corp.

For More Information, Circle No. 8, Page 123

BELT GRINDERS . . . new line of versatile, low-cost 2-1/2 in. abrasive belt machines is available. Walker-Turner Div., Rockwell Mfg. Co.

For More Information, Circle No. 9, Page 123

TEMPERATURE INDICATORS . . . available in stick, pellet and liquid form, melt when surface reaches the desired temperature. Available in ranges from 113 to 2000 F for heat-treating and heat-processing applications. Markall Co.

For More Information, Circle No. 10, Page 123

AUTOMATIC HOPPER WEIGHING . . . allows accurate weighing and release at any given point. East coast foundry suspends large hopper directly under U-shaped deflection beam which opens conveyor circuit stopping sand flow when hopper weight reaches preset load point. Hopper trap remains

open until load is discharged. Four separate switches, each of which may be set to trip at the same load point or at four different load points, may be used. Totally enclosed switches may be used for outdoor installations. W. C. Dillon Co.

For More Information, Circle No. 11, Page 123

SPEED HEAT TREATMENT . . . with scale preventative which adheres to metal at furnace temperatures forming an oxygen-tight seal; as metal cools, coating spalls off. Applications include stain-

less steel, nickle-chrome alloys, cobalt alloys, copper alloys and new exotic alloys. Applied by spraying or dipping. North American Aviation, Inc.

For More Information, Circle No. 12, Page 123

MOLTEN SALT BATH . . . increases wear and fatigue resistance of plain, alloy steels or cast irons. Easily automated with no subsequent finishing operation required. Treatment ranges from 90 to 120 min. Kolene Corp.

For More Information, Circle No. 13, Page 123

SYNTHETIC FABRIC SLINGS . . . feature light weight for safety and softness to prevent marring, scratching or denting of polished, machined or painted surfaces. High flexibility allows con-

forming to any shape, and better holding ability. American Mfg. Co.
For More Information, Circle No. 14, Page 123

CIRCULAR CHART CHANGING DEVICE . . . utilizes notching and slotting for changing at pre-selected times without manual attention. Adaptable to virtually all time and date frequency requirements; utilizes, discharges and stores as many as 40 charts in a single recorder; uses only small fraction of meter clock power. Any number of recorders can be changed at same time to automatically correlate charts with master meter charts. Maeder-Squier Co.
For More Information, Circle No. 15, Page 123

SELF-STORING AIR HOSE . . . eliminates hose reels and other storage facilities. Light weight reduces operator

fatigue. Operates to 200 psi with maximum working length of 20 t. Synflex Products Div., Samuel Moore & Co.
For More Information, Circle No. 16, Page 123

SHELL CORE BLOWER . . . will produce up to 120 cycles per hour. Core box may be rocked while investing or curing. Adjusting studs permit perfect parallelism between core box faces. Handles boxes up to 11 x 13 x 10 in. Foundry Dynamics, Div. of Maclodyne Corp.
For More Information, Circle No. 17, Page 123

WATERLESS MOLDING SAND . . . producing high-precision castings is possible with use of new sand binder. Dry binder is used with mix of 120 to 190 gfn sand, oil and a catalyst. Principal advantages are said to be reduction in gas on pour-off and use of finer sands, principal disadvantage is said to be higher initial cost of low clay content sand used. Archer-Daniels-Midland Co., Federal Foundry Supply Div.
For More Information, Circle No. 18, Page 123

SPRUE CUTTER . . . features seal at junction of post and cup. Adjustable to variety of cope heights. All parts replaceable. Meldau Foundry Tool Co.
For More Information, Circle No. 19, Page 123

CO_2 SHELL MOLDS . . . combines close-tolerance aspects of shell molding with time, labor and equipment saving features of CO_2 process. National Cylinder Gas Co.
For More Information, Circle No. 20, Page 123

UNIVERSAL CAMERA MICROSCOPE AND METALLOGRAPH . . . is self-contained instrument for visual observation, photomicrography, microprojection and drawing. Basic unit provides magnifications in range of 25-2000 X with intermediate steps. With accessory low power objectives lower limit may be extended to 5 X. May be used for research and routine metallurgy as well as for quality control and inspection. Unitron Instrument Div., United Scientific Co.
For More Information, Circle No. 21, Page 123

EPOXY FOR 500 F . . . new epoxy resin has heat resistance up to operating temperature of 500 F. Material is said to retain elasticity at higher temperatures. Marblette Corp.
For More Information, Circle No. 22, Page 123

CORE WIRES . . . made of cord-like, resin-impregnated fiber glass break up during shakeout, eliminating resorting and reforming. Cord forms to any contour, will not deform and will not weld to casting. Archer-Daniels-Midland Co.
For More Information, Circle No. 23, Page 123

ELIMINATE METAL PENETRATION . . . with new high refractory using cold setting binder. May be used as rammed facing or for lining core boxes where heavy metal sections lead to penetration. G. E. Smith, Inc.
For More Information, Circle No. 24, Page 123

PLASTIC RUBBER . . . new material for pattern and core box manufacture or repair has been developed. Resists abrasion and erosion. Suitable for other foundry applications. Dike-O-Seal Inc.
For More Information, Circle No. 25, Page 123

USE SIMPLE CRAYONS . . . to determine metal temperatures as high as 2500 F. Learn about the 80 specific temperature ratings now available in Tempilstik crayons. Tempil Corp.
For More Information, Circle No. 26, Page 123

TRIPLE DUTY . . . Moto-Truc is an in-plant electric car that can be used to carry four persons or 2000 lb of freight or tow 4-wheeled wagons. The Moto-Truc Co.
For More Information, Circle No. 27, Page 123

REACH 129 IN. HIGH . . . with high-lift rider-type material handling truck. Ideal for servicing high storage racks containing patterns, supplies and spare parts. Lewis-Shepard Products, Inc.
For More Information, Circle No. 28, Page 123

SELF LOWERING AND LIFTING TRAILER . . . lowers trailer bed to ground level for easy loading and hydraulic lifts it to riding height for towing to destination. Magline Inc.
For More Information, Circle No. 29, Page 123

LOW-LIFT PLATFORM TRUCK . . . is self propelled. Has 7000-lb capacity on platform 28 in. wide x 66 in. long x 11-1/4 in. lowered height. Erickson Power Lift Trucks, Inc.
For More Information, Circle No. 30, Page 123

DUST COLLECTOR . . . with glass filter fabric is cleaned by short blast of high pressure air alternating with small amount of reverse airflow from main fan. Intensity of action may be regulated from slight pulsation to equivalent of mechanical shaking without internal moving parts or strain on casing and structural members. Pangborn Corp.
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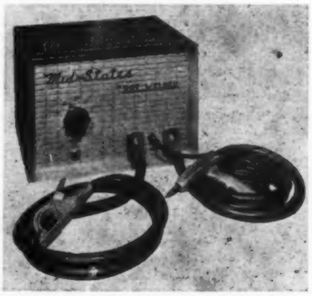
PROTECT PNEUMATIC EQUIPMENT . . . with compressed air filtering unit which removes vaporized and entrained moisture and oil, sludge, dirt and other contaminants. Combines heat exchanger, condenser-evaporator, filter element, refrigeration section and automatic condensate discharge. Residue drops into condensate collection chamber and discharged. Hankison Corp.
For More Information, Circle No. 32, Page 123

UNITIZED ALL-METAL CONVEYOR . . . withstands extreme heat and cold, resists oil and solvents and has high load capacity. Installation and maintenance costs minimized by rapid belt assembly, using one-piece frame in 10-ft sections with fully adjustable legs and floor lagging pads. Any number of horizontal, inclined or vertical sections may be combined in a one-piece conveyor. M-H Standard Corp.
For More Information, Circle No. 33, Page 123

ACOUSTICAL PHONE BOOTH . . . absorbs extraneous noises, allows normal conversations in noisy locations. Elimination of door allows free circulation of air, dispenses with glass breakage and simplifies cleaning. Various designs allow installation in difficult locations. Burgess-Manning Co.
For More Information, Circle No. 34, Page 123

SHATTERPROOF GLAZING PANES . . . resist high winds, eliminate danger of injury of personnel near windows. Pre-cut to standard sizes in clear and three colors. Filon Plastics Corp.
For More Information, Circle No. 35, Page 123

DIE REPAIR WELDING PROCESS . . . uses metal pellets, gun-type welding device and short pulses of high density electrical current to fuse metal into die cavity or scratches. Electrical impulse is short, does not harm die



metal. Die need not be pre-heated. Repairs can be made without removing die from machine. Mid-States Welder Mfg. Co.
For More Information, Circle No. 36, Page 123

EAR PROTECTOR . . . lightweight protector provides optimum noise protection for personnel working near loud noises. Bausch & Lomb Optical Co.
For More Information, Circle No. 37, Page 123

Circle No. 159, Page 123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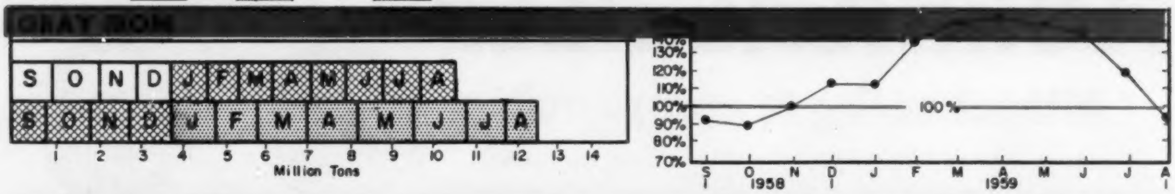
Circle No. 160, Page 123

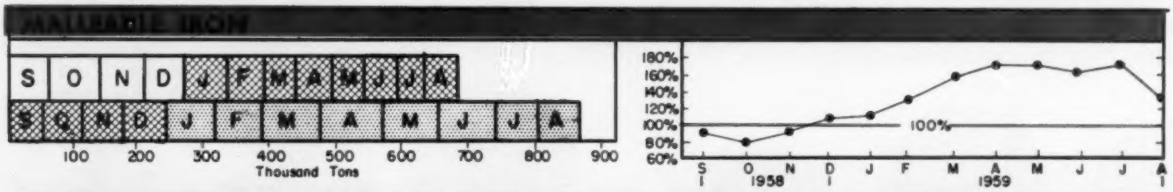
how's business . . .

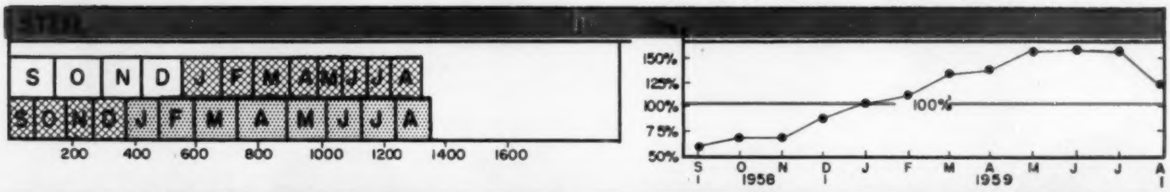
Business in the metalcasting industry appears to be leveling off. By using statistics provided by the Bureau of Census, Department of Commerce, Modern Castings has prepared this special comparison of month-to-month metalcasting shipments for the years 1957, '58 and '59. On the left, horizontal bar charts give a direct comparison of each month for the two year period September 1957 through August 1959 and the accumulative total for the two years.

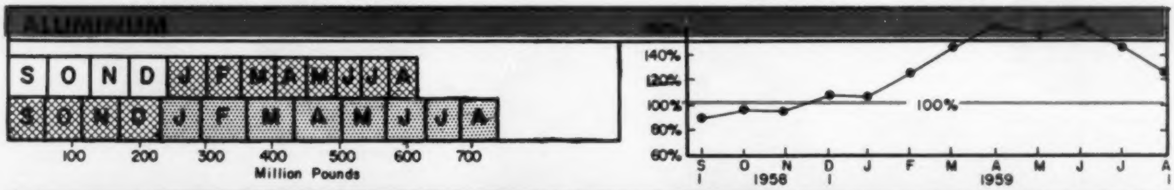
The right-hand set of graphs demonstrate the steady climb of business during the last third of 1958, continuing into 1959 and now leveling off. Shipments for each of the last 12 months are compared with the corresponding month a year previously and the ratio converted to per cent. For example, gray iron shipments were 990,139 tons in September, 1957, and 916,764 tons in September, 1958—about 93 per cent of the 1957 rate. So the curve starts at 93 per cent for September, 1958, and returns to 93 per cent for August, 1959, when shipments of 743,564 tons were slightly lower than the 802,473 tons shipped in August, 1958.

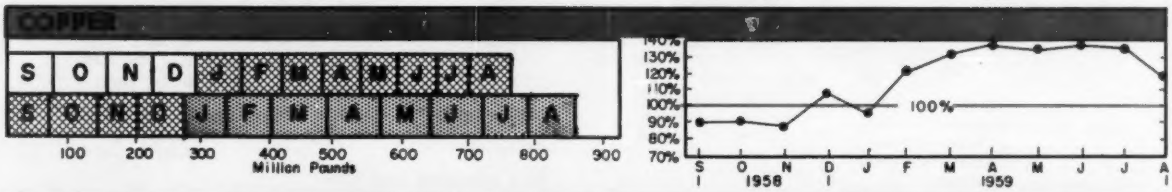
KEY---1957 1958 1959

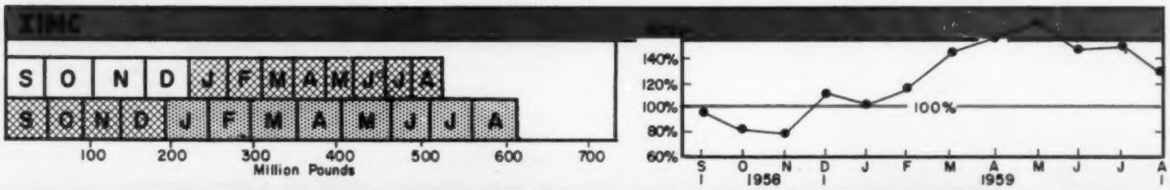


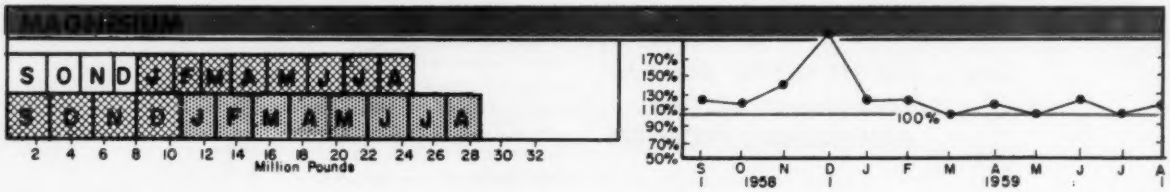












the editor's report

by Jack Schaum

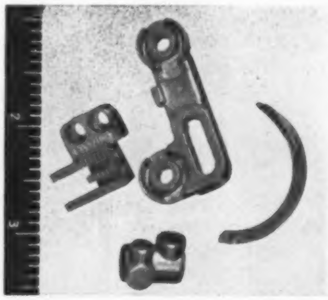
■ **High-speed x-ray movies** . . . of molten iron flowing into shell molds were shown at the 26th International Foundry Congress in Madrid. The work was done in Japan by K. Shobayashi and H. Okamoto. Flow of metal as well as occurence of entrapped air and slag inclusions was recorded by camera trained on a fluorescent screen image created by x-rays passing through mold and metal. "Saxophone" gating system proved best for test casting used in the study. See page 47 for summaries of other International papers and information on obtaining complete copies.

■ **Largest indoor sand dune** . . . is located at the Ford Motor Co., Cleveland Foundry. It measures 460 ft long x 60 ft wide x 20 ft high and holds 54,000 tons of sand.

■ **Direct refining of pig iron** . . . by injecting it with lime dust suspended in oxygen is a new process developed in France. Details presented at the 26th International Foundry Congress in Madrid tell how process can be used to convert pig iron to steel or remove sulphur, phosphorus and silicon to produce gray iron for castings.

■ **Automotive castings** are not only dated but they're also timed. Patterns have a date tag which is changed every day. They also have a small clock tag with two movable hands. Every 15 minutes the molder moves the hands to show the approximate time of the day when the molds are being made. This information helps quality control maintain close checks on all production variables contributing to the final quality of the casting.

■ **The Pfaff Sewing Machine Factory** . . . in Kaiserlautern, Germany, impresses every American foundryman who has the opportunity to make a visit there. About 1400 different parts comprise an output of a million castings a month. Practically all parts going into their sewing machines are castings. Handicapped by a serious dearth of machine tools during World War II, Pfaff turned to precision investment casting to eliminate machining. Pictured here are four as-cast ready-to-assemble sewing machine castings given to Richard R. Deas, vice-president, Hamilton Foundry, Inc., Hamilton, Ohio, during a visit.



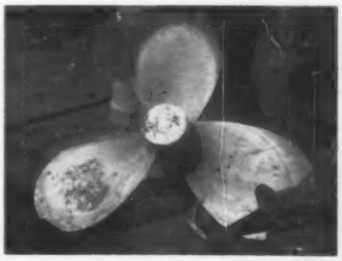
■ **Rotary reactor** . . . for continuous desulphurization of cupola iron is now on the market. Licensed process works like this: 1) molten iron flows from cupola into a revolving refractory lined rotor; 2) centrifugal force holds a 1-2-in. layer of metal against the rotor wall; 3) finely powdered desulphurizing agent is fed continuously by gravity into the reactor; 4) treated metal flows out into holding ladle as new metal flows into reactor. Metal only remains in rotor 10 to 20 seconds but sulphur is reduced to 0.020 per cent or lower.

■ **Tongue and groove** . . . core joints are being used on split cores to create concealed joints which are stronger than the cores.

■ **Ramjet engines** . . . built by Marquardt Corp. for Bomarc missiles use about 60 magnesium alloy castings. Castings are housings and ducts weighing a total of 300 lb. These magnesium-thorium (HK31A) and magnesium-rare earth (EZ33A) alloys are cast by the green sand, core sand, shell, permanent mold and investment mold processes.

■ **Aluminum alloys** . . . containing high silicon are being carefully evaluated for many automotive applications. Because this alloy family has unusual thermal stability, hardness and corrosion resistance, it may find additional applications for metal core boxes and shell pattern equipment.

■ **Test bars** . . . are attached like this to edge of bronze propellers destined for the Navy. Columbian Bronze, Brooklyn, N.Y. is participating in a new Navy program in which test bars are located at edge, center-line and tip of blade and on hub. Study should better reveal variations in physical properties throughout cast propellers.



COMPARISON of 6 MOLDING MATERIALS

1...STEEL
2...ALUMINUM
3...GREEN SAND
4...DRY SAND
5...SHELL
6...GRAPHITE

by G. L. Tingley
Lockheed Aircraft Corp.
Burbank, Calif.

During recent years, a number of new molding materials have gained widespread use in the foundry industry. To compete, each of these new materials has to show some advantage over the universally accepted sand and permanent mold materials. The purported advantages of some of these new molding materials are: (1) better dimensional control, (2) lower cost and (3) improved mechanical properties.

An investigation was undertaken by the California Division of Lockheed Aircraft Corp., in cooperation with the Linmold Co. and Niforge Engineered Castings, Inc., to evaluate the comparative effects of different molding materials on the mechanical properties of 356-T6 high purity aluminum alloy castings. The work covers an evaluation of the mechanical property variations caused by casting the same part in six different molding materials. Mold materials under consideration were green sand, dry sand, resin-sand shell, rammed graphite, steel and aluminum.

A drawing of the part appears in Fig. 1. This part was chosen because it was a convenient one from which to machine tensile specimens.

Linmold Co., Compton, Calif., made a permanent mold and six molds each from rammed graphite, dry sand, shell sand and green sand. The aluminum mold was made by the Parlanti Process at Niforge Engineered Castings, Inc.

The permanent mold was made by making a plaster pattern from a part, casting a steel mold from the pattern and finish machining the cavity for easy removal of the aluminum casting from the mold. Shrinkage was ignored since dimensional accuracy was of no concern for these tests. A sodium silicate base mold wash was used. Figure 2 shows the two halves of the permanent mold and an untrimmed part.

Graphite molds were made by ramming graphite approximately 1/2 in. to 2 in. thick adjacent to the pattern with green sand backup as shown in the cutaway mold in Fig. 3. The wide variation in graphite thickness resulted from ramming against a non-uniform shape.

The dry sand mix contained No. 120 and No. 90 sand, core oil, corn flour, water and kerosene.

The shell mix was No. 90 silica sand with a resin binder. Figure 4 shows the shell mold, a cutaway of the mold and an untrimmed part.

Green sand molds were rammed synthetic sand containing natural clay binder with approximately 5 to 5-1/2 per cent moisture content. Figure 5 shows the green sand mold, a cutaway of the mold and an untrimmed part.

The aluminum mold was made by the Parlanti Mold Process which comprises a method of controlling the even-cooling of a cast mass. The mold is made of aluminum which is surface anodized. The anodized layer, essentially Al_2O_3, has a melting point over 3600 F. The rate and flow of heat through this mold largely depends on the size and shape of the mold.

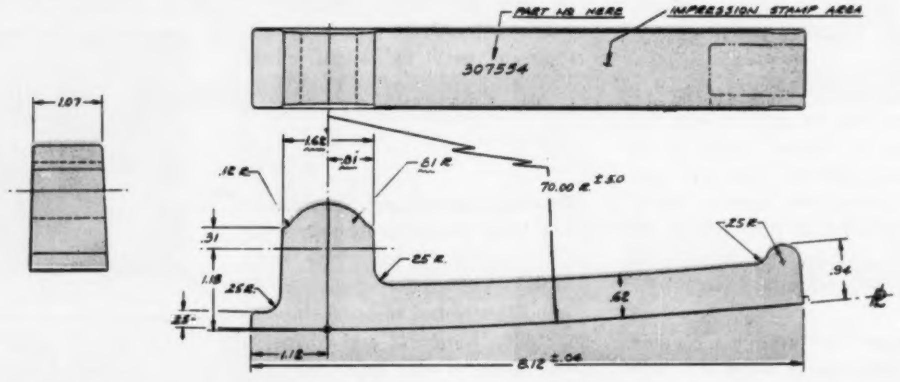


Fig. 1 . . . This part was cast in six different molding materials to evaluate mechanical property variations.

Fig. 2 . . . Untrimmed part as cast by permanent mold.

Fig. 3 . . . Rammed graphite mold, green sand back-up.

Fig. 4 . . . Shell mold, center, and cutaway of mold.

Fig. 5 . . . Green sand mold is rammed synthetic sand.

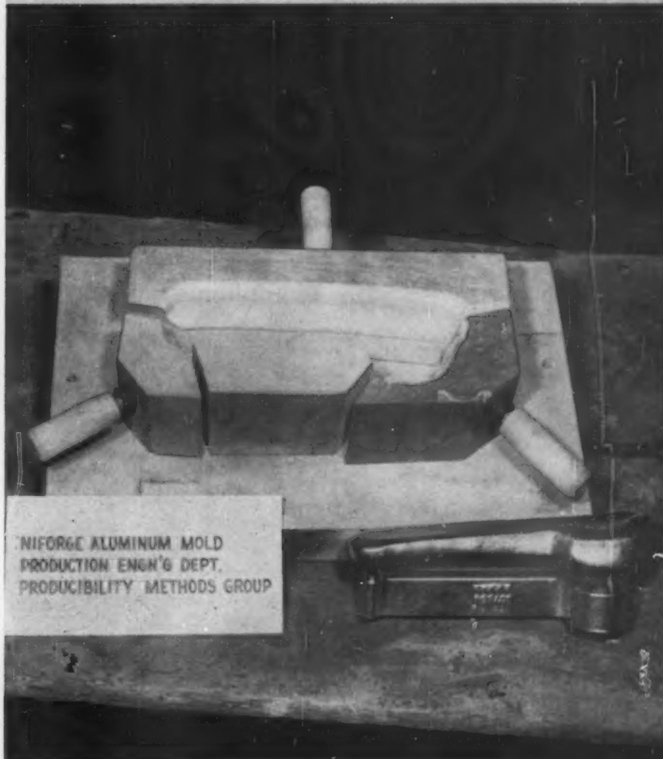


Fig. 6 . . . Aluminum mold was made in five parts.

The process makes use of the high thermal conductivity of aluminum to control the rate of heat transfer from the molten metal. Shrinkage difference for dimensional accuracy was ignored. Mold was made in five parts with riser extending over full length of the casting. The aluminum mold with the components slightly ajar rest on an aluminum plate shown in Fig. 6.

Identification of each part was related to the molding material and assigned a specimen number as shown in Table 1.

Producing the Castings

Six castings were poured in each of the six molding materials. (Total 36 castings). All parts were poured at 1300 F from a single melt using high purity 356 virgin ingot aluminum alloy. Estimated temperature of the aluminum mold was 450 F and the steel mold was 550 F when parts were poured.

All of the test parts received heat treatment in a batch as follows:

Precipitation heat treat—315 F for 4 hours.
Solution heat treat—1000 F for 12 hours.

Test parts were x-ray inspected one hundred per cent. Three of the 36 parts were rejected for excessive inclusions, i.e., foreign particles entrapped in the melt during the casting solidification process. One reject was a dry sand part (TD-5) and the remaining two were parts from shell molds (TS-2 and TS-4). No apparent correlation existed between the x-ray rejections and mechanical properties in Table 1. All parts passed dye penetrant inspection.

Standard tensile coupons were machined and tested in a 5000 pound tensile testing machine. Yield values (0.2 per cent offset) were calculated from automatic load-strain curves drawn with the aid of an extensometer.

Casting Properties

Table 1 shows mechanical properties of parts made from the steel mold and aluminum mold to be superior to parts made from the other molding materials. Dry sand, green sand, shell molds and rammed graphite have low thermal conductivities when compared to aluminum and steel. The slow dissipation of heat through the sand or graphite molds promotes large grain size and solidification shrinkage.

Specimen numbers TA-3 (made from green sand) and TD-2 (made from dry sand) were considered the two with the lowest mechanical properties. TN-3 (made from aluminum mold) and TP-4 (made from steel mold) were picked as the two specimens with the highest mechanical properties.

Figures 7 and 8 show a more uniform grain struc-

TABLE 1 — THE EFFECT OF MOLD MATERIALS ON 356-T6 ALUMINUM ALLOY CASTINGS

Mold Material	Spec.	Ultimate (1000 psi)	Yield (1000 psi)	Elongation in 2 in. Gage Length
Steel Mold	TP-1	42.2	29.9	8.0
	-2	41.4	28.8	9.5
	-3	41.4	28.7	10.5
	-4	42.0	28.6	11.5
	-5	40.2	28.7	6.5
	-6	41.2	28.6	10.0
Alum. Mold	TN-1	41.9	29.9	10.5
	-2	42.0	29.1	11.0
	-3	43.2	30.5	11.5
	-4	41.9	29.0	11.5
	-5	42.0	30.3	9.0
	-6	41.2	28.6	10.0
Green Sand Mold	TA-1	36.1	28.3	3.0
	-2	35.2	27.8	3.5
	-3	35.4	28.2	2.0
	-4	34.6	27.9	2.5
	-5	35.1	27.7	3.0
	-6	33.9	27.7	2.5
Dry Sand Mold	TD-1	34.6	28.0	2.0
	-2	34.0	28.0	2.0
	-3	34.4	28.2	2.5
	-4	34.8	28.0	3.0
	-5	34.3	27.4	3.0
	-6	34.7	27.7	2.5
Shell Mold	TS-1	35.1	27.8	2.5
	-2	35.5	27.5	2.5
	-3	36.6	27.9	3.5
	-4	34.8	27.6	2.5
	-5	36.2	27.7	3.0
	-6	35.6	28.0	2.5
Rammed Graphite Mold	TG-1	34.7	27.4	2.5
	-2	35.5	27.5	3.5
	-3	35.2	27.6	3.0
	-4	35.2	27.3	3.0
	-5	35.4	27.4	4.0
	-6	35.5	27.8	3.5

Fig. 7

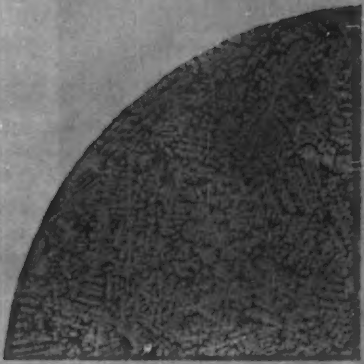
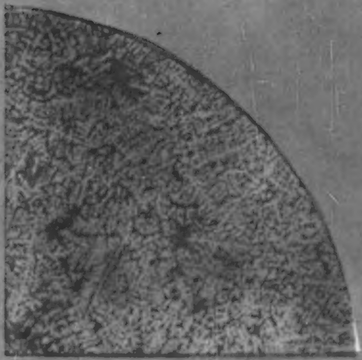


Fig. 8



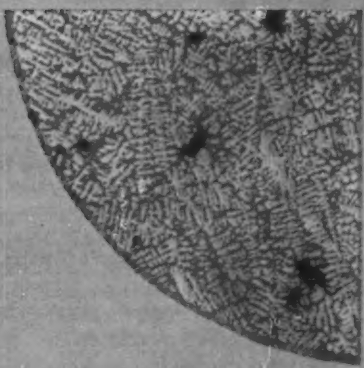


Fig. 9

Fig. 10

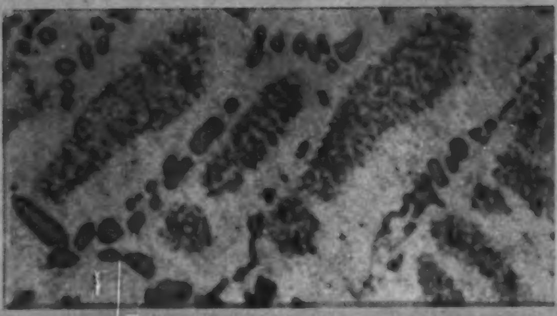


Fig. 11

Fig. 13

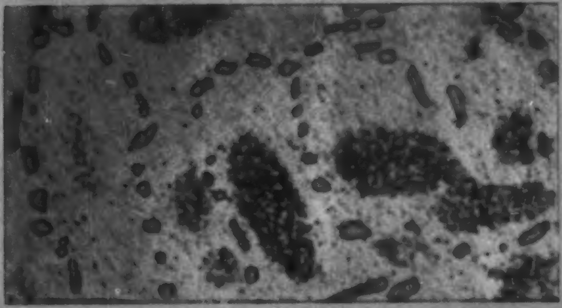


Fig. 12

Fig. 14

ture than Fig. 9 and 10 which also reveal some solidification shrinkage. Figures 11 through 14 show the grain structure of the same four specimens when etched and magnified 200 times. These photomicrographs reveal a more refined grain size in the parts made from the aluminum mold and steel mold.

Table 2 tabulates the variation in costs for the six different casting procedures. Table 3 gives the chemical composition of the high purity 356 aluminum alloy used in these tests and compares it to the chemical requirements of Federal Specification QQ-A-601, Comp. 3.

TABLE 2 — COMPARATIVE COSTS OF MOLDING PROCESSES

Type	Tooling Price	50 Pcs.* Price ea.	250 Pcs.* Price ea.	500 Pcs.* Price ea.
Steel Mold	$325.00	$1.45	$1.25	$1.25
Alum. Mold	500.00	1.42	1.22	1.22
Green Sand Mold	125.00	1.46	1.46	1.46
Dry Sand Mold	250.00	2.65	2.65	2.65
Shell Mold	375.00	2.50	2.20	2.20
Graphite Mold	125.00	1.75	1.75	1.75

*Piece price does not include amortization of tooling price.

TABLE 3 — CHEMICAL COMPOSITION OF THE HEAT

	LOCKHEED PART	QQ-A-601 Comp. 3
	%	%
Silicon	7.08	6.5 - 7.5
Copper	0.02	0.2 max.
Magnesium	0.31	0.2 - 0.4
Iron	0.09	0.6 max.
Manganese	0.01	0.35 max.
Titanium	0.08	0.25 max.
Zinc	0.03	0.3 max.
Aluminum	Rem.	Rem.

Conclusions

Based upon the results of these tests the following conclusions may be drawn:

Parts made from the steel mold and aluminum mold showed superior ductility and improved tensile and yield strengths when compared to parts made from rammed graphite molds, shell molds, dry sand molds and green sand molds.

Parts made from green sand molds, dry sand molds, shell molds and rammed graphite molds revealed approximately the same strength and ductility values when compared to each other.

Cooling rate has a definite influence on mechanical properties. The main effect of the molding material on the mechanical properties arises from its ability to extract heat from the molten metal at a fast rate which gives a finer grain structure, a more dense material and an even dispersion of constituents.

The part under consideration had a minimum cross sectional dimension of 0.62 in. — quite thick for an aircraft casting. The results of this investigation should not be applied to thinner cross sections since cooling rate will be different.

a test to control Green Sand Properties in the MOLD

All of the co-authors were active members of the AFS student chapter at the University of Wisconsin. Meyst, Mueller, Shaw and Widmoyer held Foundry Educational Foundation scholarships.

Standard 2-in. by 2-in. diameter AFS sand specimens have long been used in determining the physical properties of molding sands. However, the mold hardness and density of the standard 3 ram AFS specimen and that of the mold may be different. Usually the standard specimen density is higher than the mold density. This report shows that 2-in. by 2-in. diameter standard or nonstandard specimens and sand molds of equivalent densities and mold hardnesses can be produced. It further demonstrates that when the average mold hardness of the specimen and mold are equal, their densities are equal.

In this experimental work, molding was done on a jolt-squeeze molding machine using the pattern equipment shown in Fig. 1. Molds were made in 14-in.x17-in.x8-3/4-in. flasks. These molds were produced by four procedures: jolting alone (20 jolts, 3-in. stroke), squeezing alone (95 psi squeeze pressure), jolting followed by squeezing, and jolting followed by squeezing with a contour squeeze frame. Mold densities ranged from 64 to 87 lb per cu ft. The actual data appears in Table 1.

After stripping the pattern, mold hardness readings were taken at the parting line with a mold hardness tester. Then the mold was cut in half to allow access to the flat vertical walls of the mold cavity. Hardness was measured on both vertical walls at 1-in. increments from the parting line. Table 1 shows the averages of these readings.

In the laboratory, 2-in. by 2-in. diameter AFS specimens were produced to cover a range of densities from 69 to 100 lb per cu ft. To accomplish this predetermined weights of sand were compacted to the required 2-in. length. This amounted to 22 standard rams with a 14-lb weight for the heaviest specimen and a drop of about 1/2-in. of a 2-lb weight for the lightest.

Density measurements were made by dividing the weight (in lb) of the molds and specimens by their volumes (in cu ft). The 2-in. by 2-in. diameter specimens have a given volume (6.28 cu in.) while the molds may vary slightly in volume with the method of compaction. The mold volumes can be calculated from data on flask size, actual mold height and the mold cavity volume.

by University of Wisconsin, Department of Mining and Metallurgy, Advanced Metal Casting Class— J. Hermes D. Bautista, Gerald J. Hansen, Kyaw Htun, Roger G. Lundholm, Peter H. Meyst, Andres C. Mueller, William F. Shaw, and James R. Widmoyer.

Average mold hardness (average of three top and three bottom readings) was determined for each specimen. Table 2 gives density and mold hardness data for the specimens. The same sand was used to prepare both specimens and molds. It was a heap sand composed of No. 85 AFS bank sand, 6 per cent southern bentonite and 1.25 per cent carbonized cellulose. Moisture contents of 2.45 per cent, 2.75 per cent and 3.0 per cent were used. Sand mulling took place in a horizontal wheel muller.

Test results are summarized in Tables 1 and 2 and in Fig. 2. Figure 2 shows the relationship between mold hardness and density for the test specimens and molds. From the graph it can be seen that at a given mold hardness the densities of both specimens and molds are essentially equivalent falling within a small acceptable range. Within the range of observation, the sand moisture content does not affect the density to mold hardness relationship to any great extent. Also note that in the range of 60 to 80 mold hardness, density increases slowly, while above 80 density increases rapidly. Other properties such as green strength and dry strength are also known to increase rapidly above 80 mold hardness.

In this series of experiments it can be seen that the mold hardness and density of a mold can be reproduced in 2-in. by 2-in. diameter specimens.

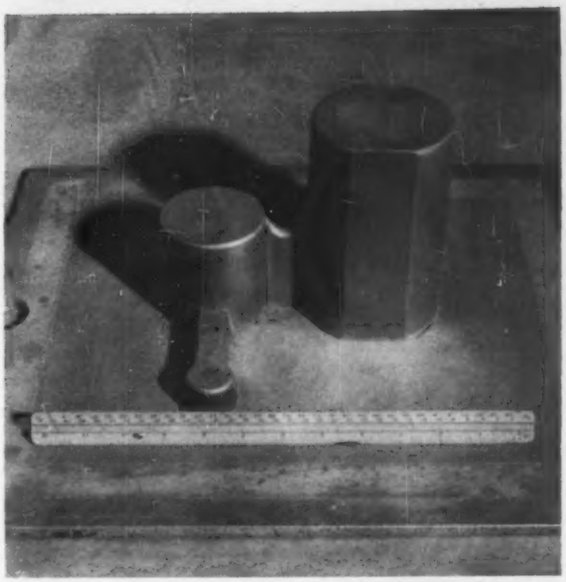


Fig. 1 . . . This pattern equipment was used with a jolt squeeze molding machine, using four different procedures to produce molds.

TABLE 1—MOLD HARDNESS AND DENSITY OF MOLDS

Compacting Method	Density (lb/cu ft)	Average mold hardness at vertical wall		
		2.45% H_2O	2.75% H_2O	3.00% H_2O
Squeeze (95 psi pressure)	64.3	37.5	42	37.5
Jolts (20 jolts)	70.0	62.2	65	69
Jolt & Squeeze	83.0	79	81	84
Jolt & Squeeze (with contour frame)	87.0	88.0	—	—
"	83.4	—	88	77
"	85.8	—	—	83

Fig. 2 . . . Mold hardness compared to density.

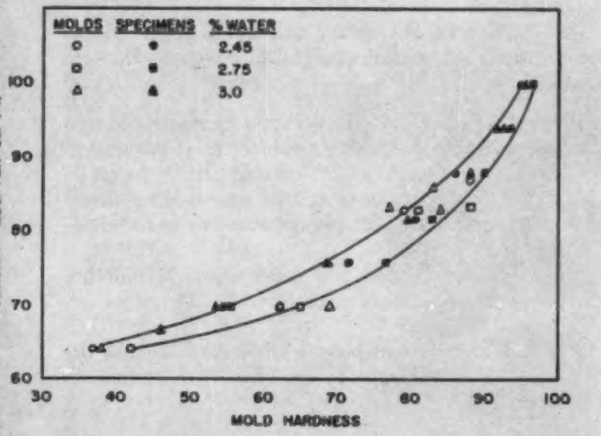


TABLE 2—MOLD HARDNESS AND DENSITY OF 2-IN. DIAMETER SPECIMENS

Sample Weight (Grams)	Density (lb/cu ft)	2 in. x 2 in. AFS Specimen Average M.H.*		
		2.45% H_2O	2.75% H_2O	3.00% H_2O
165	100.0	95	96.5	95.5
155	94.0	92.5	92.5	92.5
145	87.9	86	89.8	88
135	81.8	80.5	82.8	80
125	75.8	71.5	76.5	68.7
115	69.7	54.5	55	53.5
110	66.7	—	—	46

*Mold Hardness—Average of three readings on top and three readings on bottom.

CASTING DESIGN

by Raymond Russell
American Foundry & Machine Co.
Salt Lake City

Stresses Design Principles in

The unique features of casting design have been used by the American Foundry and Machine Co., Div. of Eimco Corp. to eliminate other fabricating processes in the process of manufacturing underground mining equipment, crawler-type earth-moving equipment, filtration and sewage clarification equipment. Castings are being made at a chapter cost per unit while providing more functional design for the many complicated components of this heavy equipment.

To further strengthen their understanding of metal-casting processes, the American Foundry and Machine Co. planned and presented a casting design symposium for company engineers and pattern-makers. The purpose of the symposium was to acquaint Eimco engineers and pattern department personnel with recent developments in the field of casting design, casting quality, casting stress analysis and pattern making. The objectives were accomplished by having experts in these fields present illustrated lectures followed by extensive question and answer period.

Organization

The symposium was organized through a group of small but active committees:

1 Symposium chairman;
foundry works manager.
2 Symposium technical chairman;
chief metallurgist, Eimco Corp.
3 Publications committee in charge of booklets, programs, hand-outs, photo slides, etc;
advertising department personnel and photography department personnel.
4 Publicity committee responsible for announcements, invitation list, and attendance records;
personnel department.
5 Entertainment of out-of-town speakers;
sales department.
6 Physical arrangements committee;
foundry supervisory personnel.

The program focused strongly on major design and foundry problems. To insure that design principles, as presented, would have continued use, a looseleaf binder was prepared, Fig. 1, and presented to each attending individual concerned with design problems within the company.

This binder is divided into four major sections:

1 Design for foundry practice.
2 Methods to overcome design problems.
3 Design of castings for end use.
4 Miscellaneous casting data and information.

Pertinent, detailed information on design principles was compiled and printed for each section. This initial release is being followed up by periodic inserts for the design binder covering current and improved foundry practices and principles.

Fig. 1 . . . This guide-book helps company engineers design better castings.

Reactions of Conferees

Approximately 125 people attended the symposium. Included were engineers from the Company's loader division, filter division, process engineers division, foundry pattern-shop personnel and a limited number of invited local engineers and patternmakers from other companies. Since the Company did not have sufficient plant facilities to house the symposium, a ball-room and dining-room were secured for the day at a local hotel.

The interest of the group was keen. A sample of the questions asked indicates the interest and thought created:

1 *ASME code allows 75 per cent of allowable tensile strength on castings subject to stress due to pressure. (This is called "casting quality factor.") Will proper emphasis on and attention to "directional solidification" permit this factor to be increased?*
2 *Are slag inclusions, gas pockets and similar imperfections influenced or partially caused by design of the part?*
3 *When a shrinkage hole is filled with weld is the joint as metallurgically sound as if there was no shrinkage?*

SYMPOSIUM

Terms of Foundry Problems

Fig. 2 . . . **Eimco** track-laying loader uses 75 cast parts from gears and housings to cast track shoes.

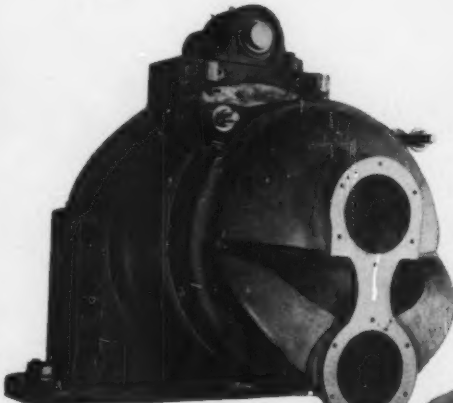
4 *Hot tear and other flaws in casting. How will they affect the casting after welding and heat treating? And how closely related should welding rod be to alloys in castings, particularly those requiring machining and later heat treatment for hardening?*

Later, several Company engineers requested conducted tours through the foundry and showed a new awareness of foundry problems and practices. Invited guests were enthusiastic.

Ken Hoen, President, Hoen Hydraulics Corp., stated, "The symposium was very worthwhile, bringing out time-tested rules as well as new ideas and design principles. We are working with high strength alloys that can have no leaks and require great strength. Design principles and stress analysis, as brought out at the symposium, are most timely."

Ken Rumel, owner of Rumel Pattern Shop, said,

Fig. 3 . . . **Over 113** different castings have to be ruggedly built for service in this Eimco excavator.



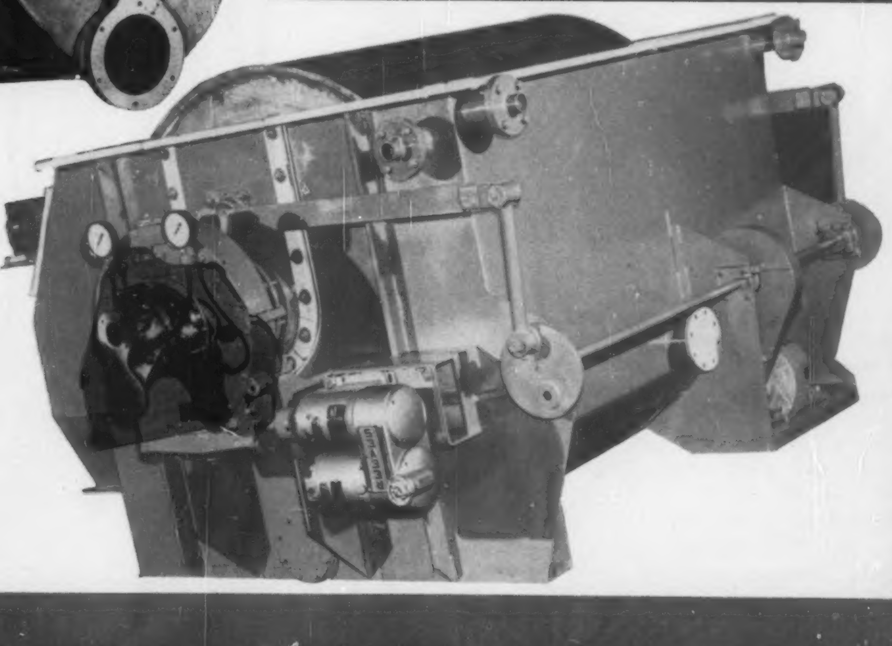


Fig. 4 . . . **Complex** valve system, above, is patented feature of filter, right. Valve is cast in 5 different metals.

"The patternmaker must indeed be familiar with the problem of engineering and design in all phases of pattern construction. The effect of your presentation of design principles to an engineering and pattern-making group was tremendous."

Figures 2-5 are visual proof of Eimco's belief in the capabilities of castings for heavy duty reliable performance.

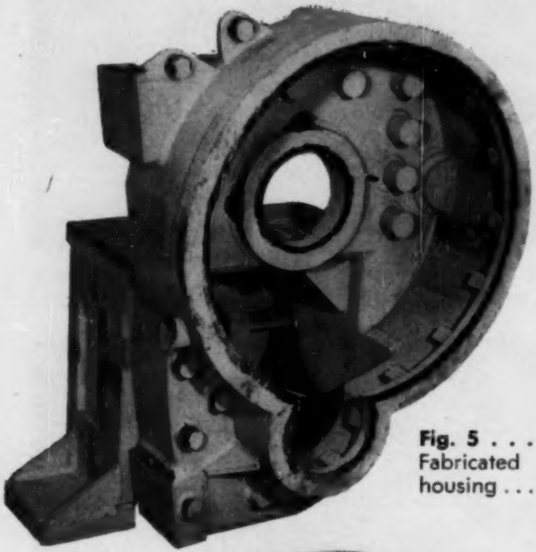
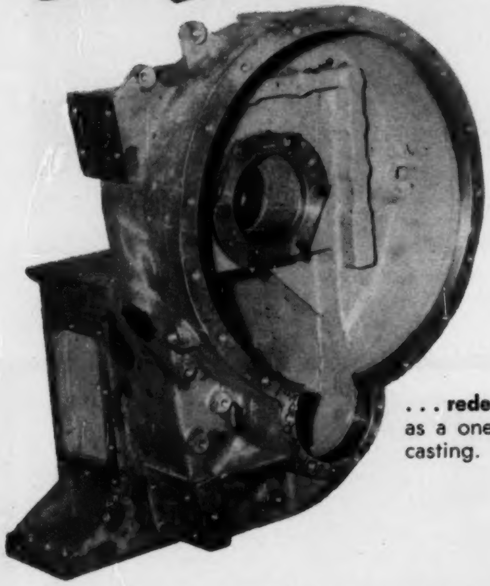


Fig. 5 . . . Fabricated housing . . .



. . . redesigned as a one piece casting.

The benefits of a casting design symposium, like any educational program, must be measured in terms of final results. The results of the program described are not simply those intangibles which plant educational programs usually try to provide; they are showing immediate and real value.

The Eimco Corp. continues to accelerate the incorporation of castings into their finished products. Maximum use of properly designed castings provide Eimco's customers with superior products at competitive cost. Equipment built from castings is giving outstanding performance under severe conditions.

A Visit to LFM Foundry

■ Want to visit the largest electric steel foundry under one roof in the Americas? The pictures surrounding this story almost make you feel like you're right there in the middle of the new foundry built by LFM Mfg. Co., Div. of Rockwell Mfg. Co., Atchison, Kan.

As you walk through the shop you will see . . . 24 tons of steel pouring from one of the big electric furnaces . . . a mobile track-mounted sand slinger backing up facing sand in a mold for a locomotive truck . . . molten metal running from a bottom pour ladle into a green sand mold . . . steel castings on the shakeout table . . . and then moving slowly down the shop on a crane hook goes another LFM specialty—a big high pressure valve body.

You will see castings ranging from 200 to 30,000 lb destined for use on diesel locomotives, heavy machinery, rock crushers, presses and oil field drilling equipment. This is LFM.

PATTERNS today and tomorrow

by Ray Olson
Southern Precision Pattern Works, Inc.
Birmingham, Ala.

Each time a new molding material or machine is introduced into the metalcasting industry the patternmaker must modify his practices to meet the changing requirements created. Today's green sand and dry sand practice bears little resemblance in some foundries to that of a few years ago. Newer sand technology and automatic mold and coremaking machines have changed the pattern picture completely. Metal core boxes used to be built as light as possible to permit a coremaker to ram and draw the boxes manually. But now heavier walls, ribs and mounting flanges are required for modern high pressure automatic core blowing and drawing machines. Higher pressure green sand molding demands heavier thick-walled patterns of more durable materials.

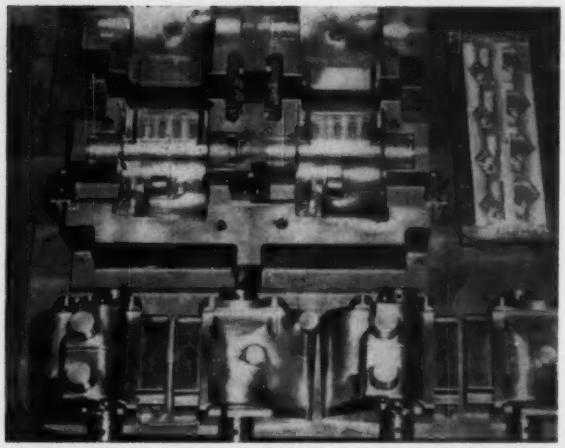
New sand-bonding processes permit cores and molds to harden before the core box or pattern is removed. Perhaps the most common of these cold processes is the CO_2 process. Special attention should be given to pattern and core-box construction for this process. Particularly important is surface finish and vent location. The amount of bonding material and gas used can be drastically reduced by the patternmaker who designs to the process.

Shell molding and coremaking is probably the most widespread of the newer foundry processes. This combination of phenolic resin and sand, applied to the surface of a heated pattern or blown into a heated core box, has created a new era of foundry technology. Shell-mold sand cores have contributed a lot toward making more accurate, better looking castings; and they have spurred other processes, both old and new, to do a better job. These developments have brought considerable pressure to bear on the patternmakers.

Pattern Engineering Needed

As the requirements for closer tolerances and higher production increase in the foundry, the demands on the pattern industry multiply. Pattern engineering is becoming a necessary profession in our industry. Pattern engineers should be familiar with every piece of molding and coremaking equipment used in a foundry. This becomes obvious when you see the complex rigging required for both pattern and core boxes on these automated processes.

In shell work, for example, pattern tolerances of



Shell core box for transmission case secures beryllium-copper loose pieces (at bottom) with guides in one-half of core box. Cams actuate forward and back movement, controlled by operating shell core machine.

one thousandth of an inch are common. This type of tolerance is needed not only because of casting requirements but also because of the shell mold rigidity. Shell molds cannot deform to compensate for minor pattern variations like green sand molds.

If a core print in the drag half of a shell mold is a few thousandths of an inch smaller than the core, you cannot push it down to the right depth. If the same portion of the plate line or pattern parting is not machined correctly, it will either hold the halves of the mold apart or create a fin and increase the casting size across the parting line. Much more care and attention must be given these details in the construction of shell patterns and shell core boxes.

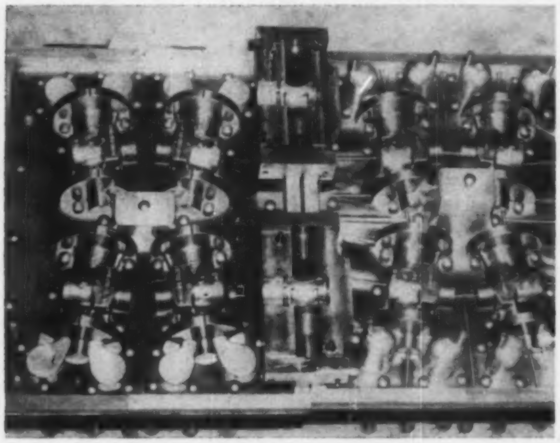
To further complicate the problem, shell equipment must operate at elevated temperatures. Loose pieces or drawbacks create a serious problem in shell core boxes. Operating with a core box temperature of approximately 500 F tends to aggravate sticking and binding of loose pieces in locating seats machined in the core-box body.

To keep loose pieces up to core-box temperature it has been common practice to operate with two sets of inserts. One set would be removed from the

core box for supplemental heating while the other was in the box making a shell core. Alternating the inserts every cycle permits production to be maintained. But manipulating hot loose pieces with thick gloves is admittedly a clumsy maneuver, with definite speed restrictions.

In our shop we have developed the application of beryllium copper alloys to movable sections of shell core boxes. This alloy combines the excellent heat conductivity, wear resistance and stability needed in shell pattern and core-box equipment. The heat conductivity is fast enough to permit steady production of shell cores with one set of loose pieces which never leave the core box.

The opening and closing motion of the core box can be utilized to actuate the drawbacks. There is no lost time and the operator never has to touch the pieces. This example is typical of the type of pattern engineering that is being done in pattern shops to further advance the shell molding and shell-core processes.



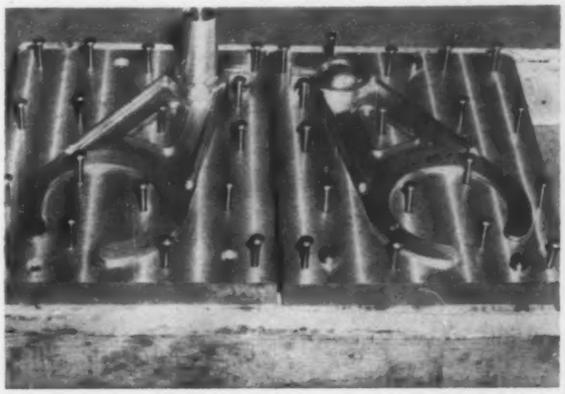
Valve body shell pattern equipment. The rigging shown here is necessary to make complete ready-to-run shell mold pattern equipment.

Future Pattern Needs

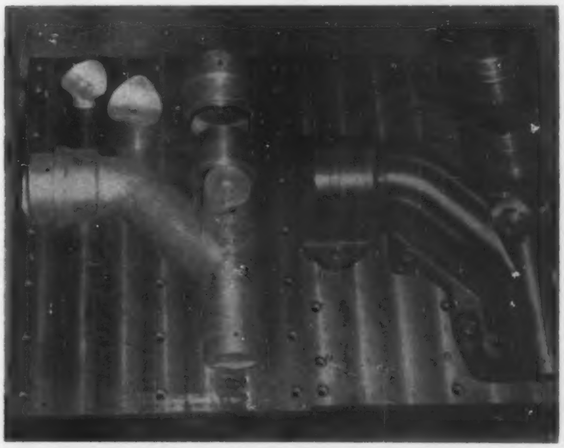
What can we expect in the future? Here are some completely new developments which could attain reality in the not too distant future.

First, with this space age absorbing much of the best metallurgical talent in the search for higher temperature metal or metal ceramic compounds, something is bound to happen. It is not illogical to assume that metallurgists will discover a permanent mold material which will stand almost infinite pouring of molten iron. This material would have to be machinable, castable and comparatively inexpensive. A development of this type would certainly lend itself to increased automation in our foundries, reduce floor space requirements and clean up the operation. Combining this mold material with shell cores would create a real production team.

Some of the earliest castings made back in the Egyptian era used ceramics. Fired clay molds or cores were used to create many of their smaller castings. Today there seems to be a new field developing in ceramic casting. Recently developed compounds combine both rigidity and collapsibility to make the casting of intricate shapes possible in ceramics. As yet the materials used are comparatively expensive and mold and coremaking operations more or less manual. So applications have been limited to high quality castings where cost is secondary. Surface finish, accuracy, and freedom from gases prevalent in sand casting make the increase in ceramic molding seem feasible.



Aluminum pattern mounted on aluminum plates rigged to run shell molds. Note combination downsprue and riser, only gating required for steel casting. Three 1/8-in. cored slots permit burning out of riser.



Interchangeable pieces for both green sand pattern and shell core box permit production of wide variety of castings from one basic pattern.

Patterns, core boxes and related equipment can be designed to produce ceramic molds and cores on a high production basis. Stripping of molds and cores from the pattern can be easily handled. The drying, assembly and firing of the molds can be mechanized. With a drop in ceramic material costs and some degree of mechanization, this process, too, will become common in our foundries. When this happens, tomorrow's patternmakers will carry their end of the load. ■ ■ ■

Lynchburg FOUNDRY

Management Development

Apprentice Training

College Graduate Training

College Co-Op

Advanced Study

TRAINING PROGRAM

By H. G. Moore, Jr.
Personnel Director
Lynchburg Foundry Co.
Lynchburg, Va.

"The money we have spent on training over the years has probably been our best investment." These were the words, in effect, spoken last fall by Henry E. McWane, President of the Lynchburg Foundry Co. The occasion was a regular apprentice graduation. More than a hundred interested persons had gathered for a dinner meeting to honor six apprentice graduates who had completed the necessary four-year course.

We use this introduction to illustrate the attitude towards training at Lynchburg Foundry. Our basic philosophy is to give an individual the opportunity to develop both himself and his job. This philosophy flows from top management and is carried throughout the organization to the extent that a yard hand will tell you, "My boss lets me do the job." Our training programs are designed to implement and support this philosophy.

Management Development

First, our management development places a responsibility on department heads to keep up with the profession by attending suitable conferences and association meetings. Those offered by American Management Association and the National Industrial Conference Board are good examples. Participation in the activities of the American Foundrymen's Society, Gray Iron Research Institute, etc., is encouraged.

At present some of our younger men from both line and staff are being assigned to the general manager and assistant general manager on a temporary basis for training. It is hoped that this phase of development will demonstrate the interdependence of departments and plants, and improve the ever-present problem of communications.

For some time we have used the management development courses offered in the summer by the universities. These courses are of special value when the trainee is headed for greater responsibility in the near future.

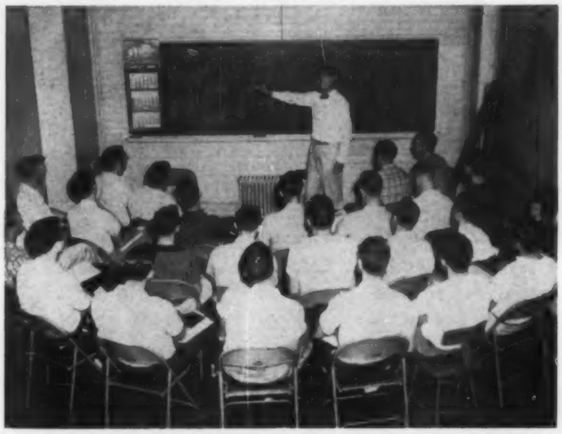
The corporate citizenship of the Company is reflected by giving individuals the time and opportunity to participate in numerous civic affairs. Accomplishments in this field hold many advantages to the community as well as the Company.

Two young executives from Lynchburg Foundry Co. attended this class in finance at the summer course for Advanced Management, School of Business Administration, Un. of Virginia.

Apprentice Charles Irwin is working at a lathe as a part of a four-year Lynchburg Foundry training course combining work experience and related classroom training.

Our line management program is beamed to plant manager and department head levels. Besides the fundamental management techniques, this group is given problem solving and case studies. Meetings are scheduled every two weeks and are always led by the Training Director.

The middle management training group is composed of our salaried supervisors. Many devices, including conferences, movies, lectures, etc., are used to teach the principles of supervision. To start with, all super-



Dr. Shirley Rosser of Lynchburg College teaches physics to a group of apprentices.

vision is taught conference leading. This group meets every other week.

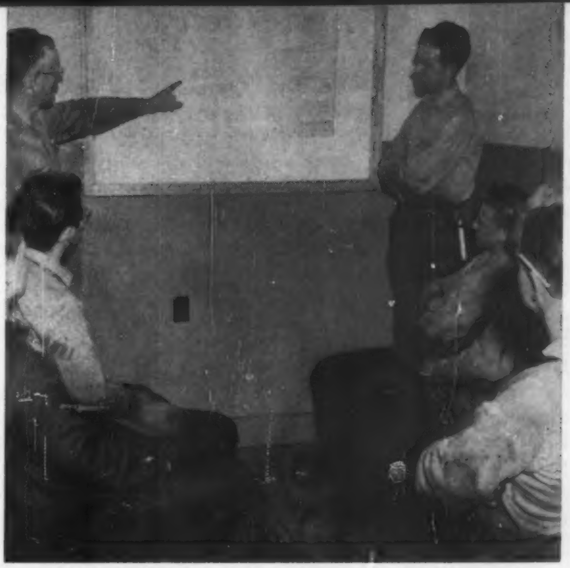
Apprentice Training

One of the best opportunities a company can offer for qualified personnel at the worker level is through an apprentice program. Here we have a planned four-year course combining work experience and related classroom training. The apprentices represent four trades: Maintenance Machinist, Electrician, Patternmaker and Foundryman. It is our source for these skills. Our work process training is given on the job and our apprentices are potential producers from the start. Complete records are kept, showing where an apprentice stands with his job training at all times.

The related training covers two areas. One division includes Mathematics, Blueprint Reading, Drawing, Work Simplification and Physics. These subjects are taught in company classes and the apprentice receives his regular rate of pay for this time.

The second division includes the trade theory for such individual trade. A competent foreman or journeyman instructs the various classes. This study is supplemented by required correspondence courses covering the trade theory. Our graduates are recognized by the Virginia Apprenticeship Council.

If we have dwelt too long on the apprentice phase of our training it is because it was our first formal program, having been founded in 1930. We have at this time fifty-four apprentices in training at our two plants. The success of the program is reflected not only in the competent graduate journeyman, but in the high percentage of our supervisors who are apprentice graduates.



Chief Electrician Jesse L. Baker conducts a training session on wiring controls.

Instructor A. H. Coleman runs a first aid class for supervisors at Lynchburg Foundry.

College Graduate Program

The college graduate trainee program has been in effect since 1950. We started with the idea of having a "pool" of college graduates in order to fill immediately our needs as job openings developed. The course was twelve to eighteen months. The plan did not work well for us. In recent years we have hired for the specific job and then tailored a training program for each individual situation. This is done by the Personnel Department and approved by the department head involved. Training always includes both plants and is largely orientation with assignments when possible. This training period is now averaging about six months. It can be overdone if the trainee spends too much time merely observing and thereby loses some of his enthusiasm.

The college co-operative program is successful and helps college-industry relations. Currently we have students alternating their studies and money-making activities between Virginia Polytechnic Institute and our plants. This is an excellent effort for all concerned.

Special programs and classes now occupy an important part of our training. Luckily we have reached the point that operations and department heads request many special sessions. Inspection has requested blueprint reading and report writing. The Cupola Department wanted sessions on effective cupola operations for all of its personnel. Supervision has been given complete First Aid courses by the American Red Cross. The Standards Department wanted refreshers on mathematics for their personnel. Sessions on industrial electronics led to the purchase of special RCA equipment. So training is ever-changing but never-ending.

Advanced Study

As to outside training, it is Company policy to pay one-half of any completed course of related training that the supervisor states will help a man on his job. These are usually correspondence courses, Dale Carnegie courses, etc.

Our Training Director reports to the Personnel Director, who in turn reports to the President. There was a time when finding instructors was a problem. This is no longer true. Staff and line department heads, supervisors, college graduate trainees, senior apprentices and skilled journeymen rise to the occasion when requested. On-the-job training, safety instructions, etc. are important parts of operations at all times.

Other sources of instructors are the colleges. Especially during the summer months college teachers are often available and are glad for an assignment. This also offers a fertile field for better understanding between the colleges and industry, a desirable goal within itself.

College-industry relations are improved through the Virginia Polytechnic Institute—Lynchburg Foundry Co. Co-op program. Here is a co-op student removing a shell mold from a shell making machine at Lynchburg. Alternate semesters he spends at V.P.I.

Lynchburg Foundry Co. General Manager Hampton W. Campbell awards diplomas to a group of apprentice graduates at commencement.

Apprentice C. W. Gowen (right) is discussing patternmaking with supervisor R. G. Patterson.

Throughout our entire training program we emphasize human relations. Companies are still run by people. Those people must be prepared to share with each other the skills, the ideas, the planning, the successes, the failures and the complexities confronting industry and modern management today. ■ ■ ■

Abstracts of International Foundry Congress Papers

MODERN CASTINGS presents here the abstracts of technical papers given at the 26th International Foundry Congress in Madrid, Spain . . . More next month.

Complete copies of these papers have been placed in the Library of the American Foundrymen's Society. After reading the abstracts, you may want complete copies for your file. Copies of the original paper, in the language of presentation, are available at 20 cents per page. The language and length of papers are given at the end of each abstract. Address orders to Book Dept., AFS, Golf & Wolf Rds., Des Plaines, Ill.

Refining Pig Iron with Oxygen and Lime-Dust by B. Trentini, P. Vayssiere, J. Francais and M. Allard.

The aim of this report is to show the interest of insufflating lime-dust suspended in pure oxygen for pig iron refining.

This is a summary of the results obtained with three refining processes:

1) The first relates to conversion steelmaking, or more specifically to the OLP (Oxygen, Lance, Powder) process, which consists in refining pig iron in a vessel of the converter type, using a lance insufflating lime-dust suspended in pure oxygen.

2) The second process relates more particularly to the open-hearth furnace, and consists in supplying part of the lime required for pig iron refining by injecting it into the bath, in highly concentrated form, through a jet of pure oxygen.

3) The third process concerns partial refining of pig iron: an oxygen-borne lime jet first brings about an easy elimination of the silicon, with an appreciable lowering of the phosphorus content. Adding fluxes to the lime and, when needed, iron oxide, makes it possible to eliminate most of the phosphorus, while keeping the major part of the carbon.

These three processes show the possibilities of development of pig iron refining through lime-dust injection in pure oxygen, both in steelmaking and in foundry practice. . . . 9 pages in French.

Penetration of Metals with Low Melting Point into Molding Sand by K. Fursund.

The investigation of penetration phenomena in connection with iron is comparatively difficult as changes take place in the sand during penetration.

This investigation almost exclusively deals with low-melting metals. The experiments have mainly been made in such a way that penetration into sand could be watched through a glass wall. This experimental method has furnished particulars of the penetration mechanism, which only with difficulty could have been obtained otherwise.

The metal penetration takes place under conditions of disequilibrium. The movements take place in jumps. For pure metals and eutectic alloys the jumps take place as soon as the surface becomes molten. The liquid metal can, even at melting point, penetrate somewhat into sand considerably colder than metal. . . . 22 pages in English.

Observations on Internal Tearing in Steel Castings by Isaac Minkoff, Charles W. Briggs and Howard F. Taylor.

Stresses acting in the cross sections of cast members have been shown to play an important part in determining tearing behavior, particularly in the presence of shrinkage cavities. This has been demonstrated for members of square and rectangular section and in the case of rings and cylinders.

For rings joined to cylinders, tearing is determined by whichever stress system predominates, that acting in the ring, or that acting in the cylinder.

The present investigation has not attempted to investigate the influence of core strength on tearing behavior. When considering the tearing of steel castings, all contributory stress systems must be considered. The observations presented in this paper are intended rather to draw attention to stress systems due to temperature distribution in the cross section of castings and their intensification with insufficient feeding. Such behavior may be the most significant in determining tearing in cast sections of small bore. . . . 4 pages in English.

The Origin and Significance of Grain Structure in Sand Castings by V. Kondic.

The term "cast structure" is defined in terms of macro- and micro-phenomena normally encountered in alloys in the cast state. The concept of grain or crystal is then singled out as one of the key features of the cast structure. The theoretical problems connected with the explanation of the origin of grains are discussed.

The concepts of nucleation and crystal growth in cast structure are outlined. Examples of practical application of this theory in foundry practice are given. The importance of grain structure in controlling properties of casting for two typical groups of alloys, i.e., solid-solution type and eutectics, is discussed.

Some recent work on the problem of explaining certain structural changes observed with commercially pure aluminum and aluminum-silicon eutectic are then reported. Fine grain structure observed with commercially pure aluminum when poured at temperatures near the melting point was found to be due to turbulence when pouring under such conditions. The fine or modified structures obtained with aluminum-silicon eutectic either by rapid cooling or by small additions of sodium were formed by essentially the same process.

In the discussion, two general points are made: first, that the present state of the theories of nucleation and crystal growth is inadequate to deal with many problems encountered with cast structure in foundry practice; and second, that the problem of the significance of grain structure in the properties and serviceability of castings is still largely unresolved. . . . 8 pages in English.

On the Production of Sound Castings of Tin Bronze by Masataka Sugiyama.

In tin bronze castings, gross shrink-

Continued on page 117

The famous Saugus cast iron pot.

Castings for the Colonies

America's first ironworks

The Saugus Ironworks Restoration, located 10 miles north of Boston, is a complete reproduction of the Colonial ironworks where probably the first successful metalcasting was done in this country.

The restoration includes a blast furnace, forge, rolling and slitting mill, wharf and warehouse—all rebuilt according to the methods of construction and materials used when the original works were first put together over 300 years ago. The Ironmaster's house, restored in 1915, also stands at the site.

Foundrymen Will Visit

A foundrymen's pilgrimage" to the Saugus Ironworks is being planned for the 65th Annual AFS Castings Congress to be held in Boston in 1963. At that time, foundrymen will view, among other relics, the famous Saugus cast iron pot (above). Legend says it was one of the first objects produced at the Ironworks.

Only recently has this legend been substantiated. A spectroanalysis was made of metal from the pot. The proportion of manganese, nickel and chromium in this sample compared favorably with proportions of similar elements present in ore, slag and fragments of cast and wrought iron found in the ironwork's ruins. This test, according to officials of the Frst Iron Works Association, Inc., of Saugus, left no doubt that the iron pot was indeed made at the Saugus Ironworks.

Largely through the efforts of John Winthrop Jr., son of the founder of Boston, a group known as the Company of Undertakers for the Iron Workes in New England," was organized in London to finance the original project. Total investments by this company reached about 15,000 pounds ($165,000), probably the first large-scale capitalistic enterprise in the American colonies.

The site selected for the pioneer ironworks had a number of natural advantages. Saugus was halfway between Boston and Salem, the two largest settlements. Nearby were ample supplies of bog iron ore, extensive woodlands to supply charcoal, a natural elevation to facilitate charging the furnace from the top and a navigable stream which could be dammed to provide the necessary water power.

While the archeological crew sifted the ruins of the ironworks for physical evidence of the ancient plant, an intensive study was made of the ironworks' records and of the lives of people who played a part in it.

Over 300 years old, this colonial ironworks near Boston stands to-day as it did when its craftsmen produced America's first cast metal products.

Colonial Economy

From scattered bits of evidence it was possible to put together a picture of economic life at Saugus three centuries ago. Records show that in 1651, the ironworks produced 160 tons of cast and wrought iron; that this cast and wrought iron sold for about $200 and $275 a ton respectively, in today's money. The ironworks normally had about 30 customers. We know that the 26 stockholders (Company of Undertakers) invested up to $165,000 in the ironworks and that the 80 employees (skilled, unskilled, part-time, full-time) averaged about 12 cents an hour for a 12-hour day, a relatively high wage for the period.

The ironworks, although built in the wilderness of the Massachusetts Bay Colony, utilized the most advanced methods of ironmaking then known. The blast furnace, which operated about 30 weeks of the year, produced just over a ton of cast iron a day. The rolling and slitting mill was one of the few existing in the world at that time. From the metal smelted in the blast furnace, skilled workmen produced cast iron objects such as pots and firebacks and crude iron sows and pigs.

Today's visitor to the Saugus Ironworks Restoration sees the ironworks as it appeared in 1650, recreated in every detail. Key structure is the stone blast furnace built with many of the stones used in the original furnace.

Although no iron is made today at the Saugus Ironworks Restoration much of the ironworks is operative. Water rushes along wooden troughs to turn the plant's seven water wheels which in turn operate massive leather bellows, the giant forge hammer and the complex rolling and slitting machinery. Smoke rising from the ironworks' chimneys lends added realism to the scene.

To charge the furnace, layers of bog ore, charcoal and Nahant rock ore were dumped into the furnace top. As the charge settled, more layers were added.

Sow bars like this were produced by breaking tap plug at furnace base, the metal filling molds in floor.

A Mesage To Management About:

by E. W. Horlebein, *President*
Gibson & Kirk Co.
Baltimore, Md.

DEPRECIATION

The recent MODERN CASTINGS article on *Depreciation* by Irving Elbaum* was an excellent presentation of this subject. This and similar articles, coupled with the efforts of several foundry trade associations, have done a remarkable job of educating foundrymen on the importance of good accounting practices.

Many foundry operations have grown "like Topsy" and the bookkeeping procedures developed similarly. Accounting practices were left to the discretion of the owner, some member of the family or an individual who has become somewhat "set" in his or her ways.

My thoughts at the moment are not concerned with those of the industry who apply reasonably good accounting practice in their operations. Instead, they concern the far larger number of foundries who apparently do not realize how to make money with a greater knowledge of costs and taxes. Instead they bury themselves in today's casting problems, today's deliveries and tomorrow's source of business. Perhaps part of the reason for this lack of interest lies in our current approach to the subject. Are we making the details too complicated to be absorbed readily?

Let's take the matter of depreciation as an illustration. What should be the starting point in a foundryman's handling of this matter? One method might be as follows:

- *First*: Establish today's value of your buildings.
- *Second*: Establish today's value of your equipment.

These two items are the first stumbling blocks the operator finds himself up against. Especially if he has made no previous attempts to include depreciation in with his operating expenses.

Back in the early 1920's the writer found himself facing the same impasse. In my case, the situation was solved by calling in an outside appraisal company to set up these values. Other methods, however, are available for those who find themselves at this crossroad.

With values determined, then you must establish depreciation rates acceptable to the tax officials. Rates often used are: two per cent on buildings, based on a life of fifty years; and ten per cent on machinery based on a ten-year life. In a number of instances and localities these two rates have met with some objection. But once these major road blocks shrink to simple and understandable proportions, then a relatively few bookkeeping entries take care of the whole situation. And a lot fewer dollars go out for income taxes.

Perhaps the foundry industry should sponsor an educational program aimed at creating a desire to maintain some semblance of cost keeping and proper procedures of accounting. Then, once the desire to do so is generated, follow up with the elementary processes necessary to put it into effect. Such effort will help build a stronger metalcasting industry and develop healthy management direction.

Published in August 1959 issue of MODERN CASTINGS, page 34.

1960 CASTINGS CONGRESS PAPERS

- The technical articles apearing in this preview section of MODERN CASTINGS are the official 1960 AFS Castings Congress papers — the most authoritative technical information available to the metalcasting industry.

  Nearly 100 technical papers scheduled for presentation at the 64th Castings Congres of the American Foundrymen's Society at Philadelphia, May 9-13, 1960, will first be officially preprinted here.

- Readers planning to participate in oral discussion of these papers during the 64th Castings Congress are advised to bring them to the technical sessions for ready reference.

- Written discussion of these papers is welcomed and will be included in the publication of the 1960 AFS TRANSACTIONS. Discussions should be submitted to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

FEEDING DISTANCE OF RISERS FOR GRAY IRON CASTINGS

Progress Report
Gray Iron Division
Sponsored by
AFS Training & Research Institute
by G. K. Turnbull, H. D. Merchant and J. F. Wallace

ABSTRACT

Knowledge of feeding distances of gray iron castings will aid in the selection of proper location and number of risers to be used. To minimize mold wall movement, rigid molds were used in this phase of the research to determine feeding distances. An attempt was made to exceed feeding distances by feeding long lengths with one riser. Simple, uniform sectioned castings of unalloyed hypoeutectic gray iron were used. Some riser volume was found to be necessary to compensate for liquid shrinkage in cooling and solidification contraction accompanying austenitic dendritic solidification. As the carbon equivalent decreases solidification contraction increases.

INTRODUCTION

This is a progress report on work in the feeding distance of risers for gray iron castings sponsored at Case Institute of Technology by the American Foundrymen's Society, and performed under the direction of the Research Committee of the Gray Iron Division.* The work is being continued under the same sponsorship and direction to investigate other variables of the performance of risers in gray iron.

The majority of cast metals undergo considerable liquid and solidification contraction during their cooling from the pouring temperature and eventual solidification. Risers are provided to compensate for this contraction and to produce a casting free from shrinkage defects. Risers serve two purposes:

1) To compensate for the volumetric contraction of the metal.
2) To create temperature gradients in the casting such that channels of metal supply are open from the risers to all parts of the solidifying casting as required.

Risers usually cannot supply feed metal more than a certain finite distance. The maximum zone over which the riser can supply this feed metal is known as the feeding distance of the riser. The application of the term feeding distance to gray iron is not strictly accurate because of the self feeding of this metal as will be discussed later.

LITERATURE REVIEW

In the last two decades, quantitative methods of risering castings have been developed. Chvorinov[1] initiated the development with his theory of the solidification times of castings. Caine[2] and the Naval Research Laboratory[3] presented methods for dimensioning of risers for steel castings. Similarly, Bishop and Ackerlind[4] and Wallace and Evans[5] described methods for nodular iron and gray iron, respectively. Merchant[6] suggested a general method whereby it is possible to dimension the risers of simple shaped castings cast in any metal if the shrinkage characteristics of the metal are known. The Naval Research Laboratory[7,8,9,10] established the feeding distances of risers for steel casting for a number of solidification variables.

Depending upon the geometery of the casting, a minimum temperature gradient is necessary in most cases to assure proper feeding. The temperature gradient between two points in a given casting shape is a function of metal and mold properties and conditions. If a riser is so located that the metal and mold properties result in insufficient thermal gradients to assure proper feeding, then centerline or dispersed porosity will result. This shrinkage is usually located in the central thermal zone of the casting, since the heating effect of the riser and cooling influence of the end of the casting produce the required thermal gradients in the areas of the casting adjacent to each.

While considerable data on the feeding distance of risers for steel castings are available, little information is published for other casting alloys. However, the solidification characteristics of many of these alloys are known,[11] and engineering estimates of the feeding distance of these metals are possible.

SOLIDIFICATION PROCESS

Gray iron does not solidify in the solid-wall, progressive manner demonstrated by steel, but involves a simultaneous formation of solid constituents of

G. K. TURNBULL and H. D. MERCHANT are Graduate Assistants, and J. F. WALLACE is Assoc. Prof., Case Institute of Technology, Cleveland.

*Members of the Research Committee of the Gray Iron Division of the AFS are: J. S. Vanick, *Chairman*, R. A. Clark, W. W. Edens, G. W. Gilchrist, R. Gregg, O. Meriwether, G. P. Phillips, J. E. Rehder and C. F. Walton.

TABLE 1 — DETAILS OF GATES AND RISERS

Heat No.	Casting Size, in.	Riser Dia., in.	Riser Height, in.	Riser Neck Dimensions, in.	Sprue Top, sq in.	Sprue Choke, sq in.	Runner Area, sq in.	Pouring Time, sec.
1, 2, 3, 4	Bar, 1 x 1 x 60	2	3*	0.5 long x 0.8 dia.	0.47	0.23	1.00	5
1, 3	Bar, 2 x 2 x 60	3	4*	1 long x 1.5 dia.	0.60	0.30	1.20	18
1, 2	Plate, thick —1, radius —60	6	8	**	5.56	2.78	11.20	40
3	Plate, thick —1, radius —60	7	9	**	5.56	2.78	11.20	40

*Plus hemispherical bottom section.
**Riser flat on bottom, one half of bottom surface rests on plate surface.

primary austenite and eutectic at different depths within the casting. Thus, large isothermal zones result in a gray iron casting rendering it susceptible to shrinkage defects. These defects frequently do not occur because of the well-known "self-feeding" during graphite precipitation occurring with the eutectic solidification. This phenomenon has resulted in statements[11,12] that the feeding distances in gray iron are essentially semi-infinite.

This does not mean that risering is not necessary in gray iron, however, because the requirement of a substantial amount of feed metal may exist before and during the formation of dendrites of primary austenite. Mold wall movement may markedly influence riser requirements.

Mold cavity enlargement has been shown to be a major consideration in feeding gray iron castings.[13,14,15] This enlargement occurs primarily in green sand molds as a result of the moisture in the sand, hydraulic pressure of molten iron and the push occurring during eutectic expansion. Since gray iron exhibits a mushy-type solidification, it has a tendency to follow the mold wall throughout solidification, and the problem of swollen castings is particularly severe with this metal.

Since the majority of this mold cavity enlargement ensues as the result of eutectic solidification during the latter stages of freezing, it imposes a severe risering problem. This is because the movement of feed metal from the riser is impeded by the solid constituents blocking the feed channels. Mold cavity enlargement is not a serious problem with inherently rigid molds such as dry, core or CO_2-set molds. In fact the mold cavity can even be reduced for large chunky castings produced in these molds, or in molds containing large cores, with the result that feed metal requirements are reduced.[5]

PURPOSE OF STUDY

It was the purpose of this study to determine the feeding distances of gray iron castings in order to permit accurate selection of the number and location of risers. The first stage of the research was confined to a nondialating or firm mold, so that the effect of mold wall movement could be minimized. An attempt was made to feed long distances in the casting with one riser, and to extend these distances over sections that were obviously semi-infinite from a thermal standpoint. These long lengths were selected in a deliberate attempt to exceed the feeding distances of gray iron, if a limit to the feeding distance of adequate risers does exist.

Adequate risers[5] were selected so that sufficient feed metal was available for the casting, and only the problem of fluid transport or feeding distance need be considered. The contention that feeding distances in gray iron were unlimited was primarily applied to low strength, slightly hypoeutectic gray irons. The compositions selected for this investigation included the entire field of commercial hypoeutectic gray irons, from mildly to strongly hypoeutectic, so that the feeding distance for the entire range could be established.

PROCEDURE

The cast sections employed in this investigation were two bars 1 x 1 x 60 in. long and 2 x 2 x 60 in. long, and one semicircular plate section 1 in. thick with a 60 in. radius. The risers were located at one end of the bars and at mid-length on the straight side of the plates. Risers and riser necks were dimensioned according to formulas developed in a recent investigation,[5] and were designed to be adequate for the size of casting and type of iron poured. All castings were single gated tangentially into the riser, utilizing the optimum pouring times and gating systems recommended by another recent progress report.[16]

Risers on the bar castings were closed top; plate casting risers were open top with a mild exothermic addition. Details of the pouring times, gating systems, risers and riser necks are given in Table 1. The appearance of typical bar and plate castings is shown in Fig. 1.

Four heats of castings were poured with carbon equivalents of from 4.1 to 3.3 per cent. The two bar and one plate castings were poured from the first three heats; the two sizes of bars were cast from heat four. All iron was melted in a commercial, hot blast, acid-lined, 54 in. diameter cupola and transferred to a holding ladle. Iron was tapped from the holding ladle into preheated hand-operated ladles suspended from a crane and poured into the molds. The cupola charge consisted of various amounts of pig iron, steel and gray iron scrap with small additions of silicon carbide and ferrosilicon.

The approximate cupola tapping, holding ladle tapping and pouring temperatures were 2800, 2650 and 2550 F, respectively, as determined by optical

pyrometer. High strength iron heats (2, 3 and 4) were inoculated in the ladle with 0.30 per cent silicon as ferrosilicon of a controlled aluminum and calcium content (1.80 per cent Al, 0.30 per cent Ca). Final chemical composition and pouring or teeming temperatures of the heats are contained in Table 2.

MOLDING SAND USED

The castings were rammed in a molding sand that was designed to remain rigid during pouring and solidification, thereby avoiding mold cavity expansion. The first heat was rammed in a sodium silicate bonded molding sand (Michigan Lake sand, AFS No. 50 fineness) that was set after ramming by gassing with CO_2. The remaining three heats were rammed in a similar sand bonded with a cold setting core oil. All castings were poured in a horizontal, leveled position after the addition of weights to the top surface of the cope. A 2 in. layer of sand surrounded all parts of the casting to prevent rapid loss of heat at any location. The castings were allowed to solidify without moving, and were cooled in the mold to below 900 F before shakeout.

SPECIMEN INSPECTION

After cooling to room temperature, all castings were sand blasted and inspected for surface irregularities, sinks and other defects. A 1 in. thick strip was cut from each plate section. This strip bisected the 180° plate, and was cut through the center of the riser. The bars and the strip from the plate were examined radiographically in a direction parallel to the horizontal cast surfaces. The 1 in. thick pieces were examined by 250 kv x-ray equipment, and the 2 in. thick pieces by gamma-ray inspection. As a further check, six equidistanced slices were cut from the bars.

These slices and the 1 in. strips from the semicircular plate were etched for 24 hr with 10 per cent sulfuric acid, cleaned and examined visually for shrinkage. Brinell hardness readings were taken at the center of the slices cut from the bars and at the center of the side of the strip cut from the plates. All risers were sectioned vertically in the center, etched and examined visually for shrinkage in a manner similar to the procedure for the strips.

Wedge-type (2 in. high by 1¼-in. base) chill tests and vertical bars (1.2 in. diameter by 20 in. long) were cast for all heats in oil-bonded, baked core sand. These latter tests were taken both before and after inoculation on heats 3 and 4. The chills were

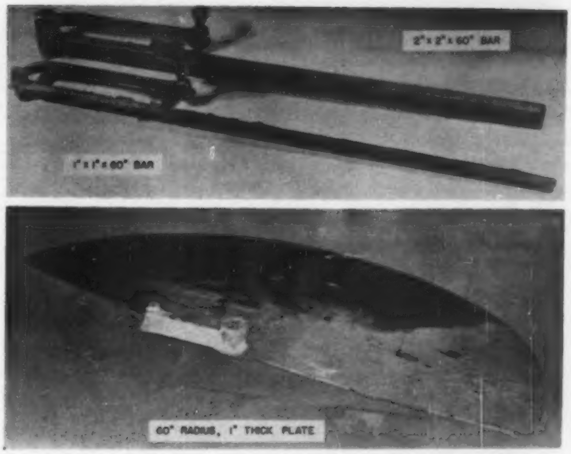


Fig. 1 — As-cast gray iron bars and plate castings used in this phase of research showing gate and riser attached. Note distances given for each type of casting.

fractured and examined. White edges of the chill were crushed and analyzed for carbon content; the remaining elements were determined from the drillings from the runner of one of the castings of each heat. After measuring Brinell hardness, the 1.2 in. diameter test bars were machined to standard 0.505 in. diameter, 2 in. gage length, threaded tensile bars and tested for tensile strength.

RESULTS AND DISCUSSION

All bar and plate gray iron castings appeared sound visually and radiographically. No draws or sinks were detected by close examination of all surfaces, and normal pattern shrinkage was obtained (somewhat smaller shrinkage on heat 1 than on heats 2, 3 and 4). Radiographic examination failed to reveal any internal shrinkage defects in any casting. Typical radiographs of sections from the sound 1 x 1 in. and 2 x 2 in. bars and 1 in. strip cut from the semicircular plate are shown in Fig. 2. Some surface roughness was found on the cope surface of the plate casting, but this was attributed to sand failure.

No evidence of shrinkage defects of any type was observed on the etched slices from the bar and plate sections. Soundness of these etched sections is indicated in Figs. 3 and 4. It is also noted that no internal unsoundness was found in any sectioned and etched risers, as illustrated in Fig. 5. Risers of the low carbon equivalent irons were sunken at the

TABLE 2 — CHEMICAL COMPOSITION AND TEMPERATURES OF HEATS

	Final Chemical Composition									Avg. Temp., F		
Heat No.	C, %	Si, %	S, %	P, %	Mn, %	Cr, %	Ni, %	Mo, %	C.E., %	Cupola Tapping	Holding-Ladle Tapping	Ladle Pouring
1 (not inoculated)	3.44	1.92	0.134	0.077	0.72	0.08	0.16	0.05	4.11	2800	2660	2520
2 (inoculated)	3.26	1.56	0.120	0.057	0.65	0.13	0.22	0.07	3.80	2750	2650	2550
3 (inoculated)	3.28	1.62	0.099	0.062	0.64	0.02	0.07	0.03	3.84	2770	2690	2543
4 (inoculated)	2.91	1.00	0.06	0.055	0.43	0.11	0.16	0.06	3.26	2700	2620	2480

*Carbon Equivalent = % C + ⅓ (% Si + % P).

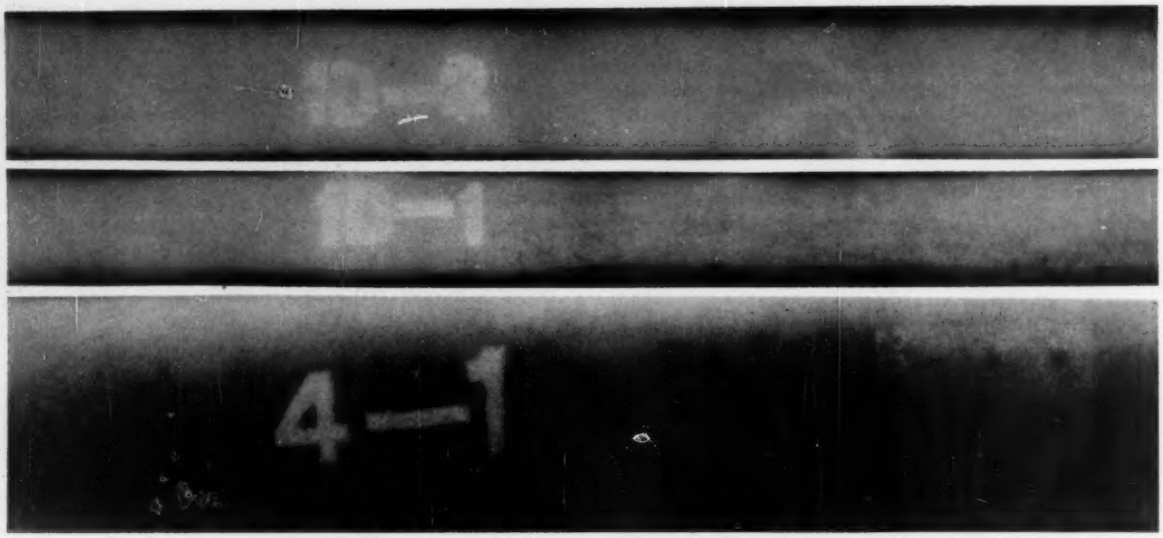


Fig. 2 — Typical radiographs of sections about 24 and 42 in. from riser end. Top, 1 in. thick by 60 in. long plate from heat 1; center, 1 x 1 x 60 in. long bar from heat 1; bottom, 2 x 2 x 60 in. long bar from heat 4.

top; the higher carbon equivalent irons had slightly dished or flat tops, or in some cases exhibited slight exudations.

Results obtained for heats 1 and 3 included 1 x 1 x 60 in., 2 x 2 x 60 in. bars and 1 in. thick 60 in. radius semicircular plates. The 2 x 2 in. bar broke out of the mold on heat 2 and was not available. The plate casting was not poured on heat 4, and the 1 x 1 in. bar was white iron for this high strength composition even though inoculated. For this reason, only the 2 x 2 x 60 in. bar in heat 4 and the 1 x 1 x 60 in. and 1 in. thick plate in heat 2 were tested.

GRAY IRON SELF FEEDING

It is indicated by these results that, when gray iron is cast in a rigid mold, the self feeding produced by the graphite eutectic expansion is sufficient to comply with feed metal needs, provided a riser is available to satisfy the initial liquid and solidification contraction requirements. The amount of liquid contraction will depend on the superheat, and the solidification contraction is determined by the carbon equivalent. In this investigation, however, the conclusions on effective self feeding can be made for a range of chemical compositions from 3.26 to 4.11 per cent carbon equivalence, as shown by the analysis in Table 2.

Apparently, the feeding distance of adequate gray iron risers for uniform, simple shapes poured in rigid molds is unlimited for all practical purposes. The long lengths of 60 in. are sufficient to completely remove any thermal gradient from the riser end of the casting over most of the length. Under these conditions, the riser could not be expected to provide feed metal over the entire length, and the casting soundness must be attributed to the self feeding of the iron. This condition, however, would be greatly influenced by expanding green sand molds.

Results of the longitudinal hardness survey at the center of slices in bars and of strips in plates are presented in Table 3. Hardness at different sections provides confirmatory evidence of temperature gradients that existed at different points along the length during solidification and cooling of the casting; the high Brinell readings indicating a rapid

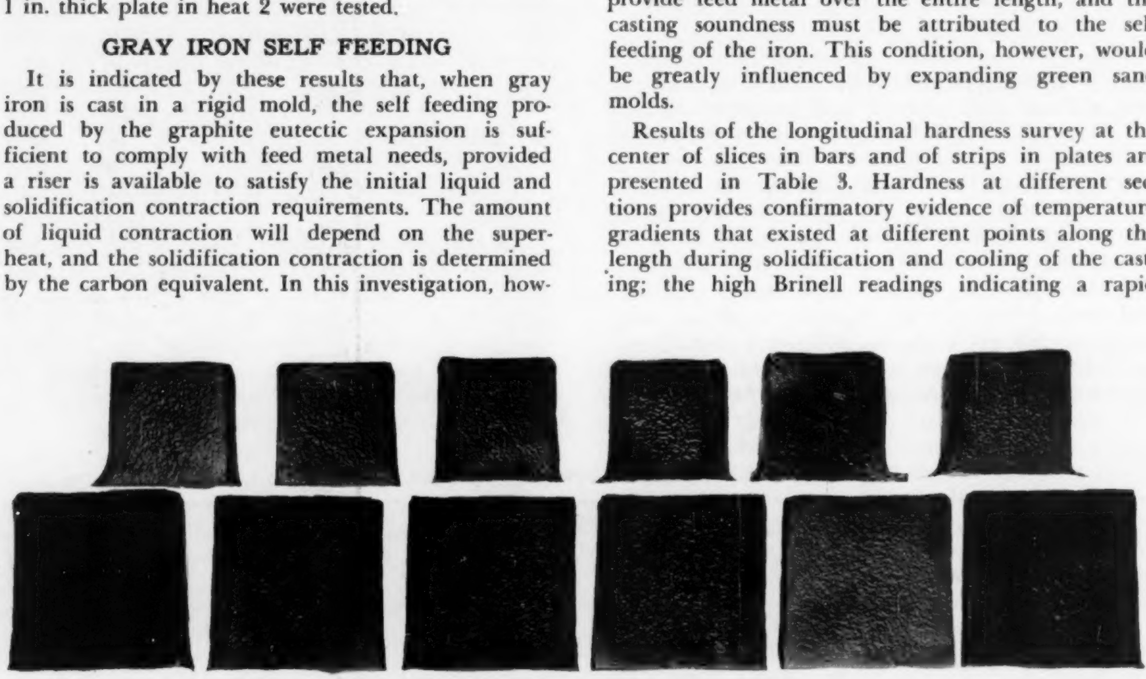


Fig. 3 — Etched transverse slices from bars. Top, 1 x 1 x 60 in. bar; bottom, 2 x 2 x 60 in. bar. Distances from riser end of bars, left to right, 1 in., 12 in., 24 in., 36 in., 48 in. and 59 in.

Fig. 4 — Typical etched longitudinal section from a plate 1 in. thick and 60 in. long. Section taken from about 24 in. to 42 in. from riser end. Heat 3.

rate of cooling and vice versa. As anticipated, hardness readings at the riser end are the lowest indicating slower cooling rates, and those at the chilled end are the highest because of the rapid rates of cooling at these locations. The central section of the bars shows only small variations because of their uniform cooling rates. Higher hardness zones at the outside of the plates are not as pronounced as in the bars.

Fractures of the chill wedges from different heats are shown in Fig. 6. Brinell hardness, tensile strength, depth of chill in chill wedge fractures and tendency toward draws in risers are summarized for each heat in Table 4. As might be expected, all of these properties increase with decreasing carbon equivalent; inoculation decreases the chilling tendency.

CONCLUSIONS

1. Feeding distance, of adequate risers on simple, uniform sectioned gray iron castings of all unalloyed, hypoeutectic gray iron cast in rigid molds is unlimited.
2. Appearance of the risers in this investigation confirms the fact that some riser volume is necessary to compensate for liquid shrinkage in cooling from the pouring temperature to liquidus temperature and the solidification contraction accompanying the austenitic dendritic solidification. The amount of solidification contraction increases as the carbon equivalent decreases.

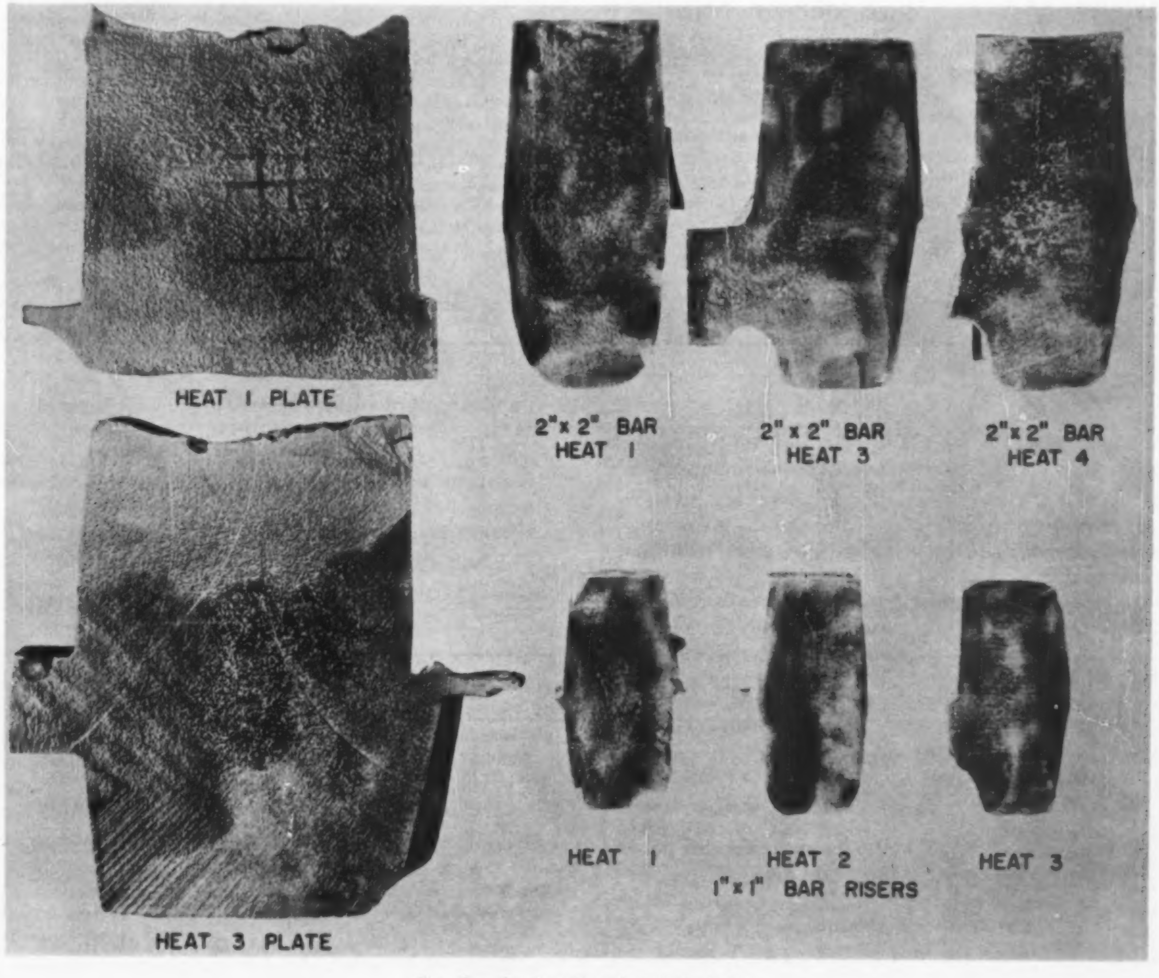


Fig. 5 — Sectioned and etched risers.

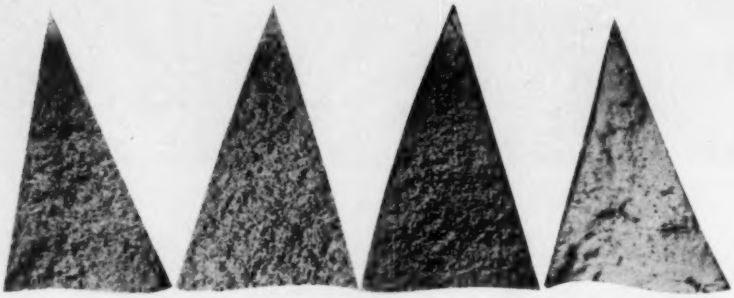


Fig. 6 — Fractured surface of chill wedges from four heats. Left to right, heat 1 not inoculated; heats 2, 3 and 4, inoculated.

ACKNOWLEDGMENTS

The authors are indebted to the Research Committee of the Gray Iron Division of AFS, J. S. Vanick, *Chairman,* for their sponsorship and great assistance throughout all phases of this investigation. The assistance of Superior Foundry, Inc., Cleveland, in making all patterns, molds and melting and pouring all of the castings, is gratefully acknowletlged. The personnel of this company were most helpful.

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TABLE 3 — BRINELL HARDNESS READINGS AT VARIOUS LOCATIONS IN CASTINGS

		Brinell Hardness					
Heat No.	Casting	At Riser	1 ft from Riser	2 ft from Riser	3 ft from Riser	4 ft from Riser	1 in from Chill End of Casting
1	1 x 1 in. Bar	167	183	175	183	183	196
	2 x 2 in. Bar	166	170	170	174	174	179
	1 in. Thick Plate	131	163	163	160	146	156
2	1 x 1 in. Bar	202	217	217	229	229	255
	1 in. Thick Plate	170	175	179	179	183	187
3	1 x 1 in. Bar	207	212	217	217	223	228
	2 x 2 in. Bar	183	212	192	192	192	202
	1 in. Thick Plate	170	166	168	183	186	183
4	2 x 2 in. Bar	207	207	217	217	207	255

TABLE 4 — COMPOSITION, CHILL TEST AND MECHANICAL PROPERTY DATA

Heat No.	Carbon Equivalent, %	Brinell Hardness	Tensile Strength, lb/sq in.	Depth of Chill in Chill Wedge, in.	Dish in Top of Riser
1	4.11	171	29,100	1/16	Only in plates
2[A] (Inoculated)	3.80	213	38.150	1/8	None
3 (Inoculated)	3.84	196	34,950	1/8	Only in plates
4[B] (Inoculated)	3.26	247	46,100	Few Gray Spots	In bars

A — No plate cast in heat 2.

B — 1 x 1 in. bars were white; no plate cast.

NOTE: The tensile strengths are somewhat low because the 1.2 in. diameter bars were oversize, and the manganese content was somewhat low in some cases.

INCLUSION IDENTIFICATION IN MAGNESIUM ALLOY CASTINGS

by B. Lagowski and W. A. Pollard

ABSTRACT

Three types of inclusions found in EZ33A and ZH62A magnesium alloy castings were examined by radiographic, metallographic, x-ray diffraction and spectrographic techniques. The results showed that the inclusions of the first type were caused by entrained sand grains, those of the second type by iron-zirconium compounds and those of the third type by aluminium-zirconium compounds.

INTRODUCTION

This investigation was initiated to identify three types of inclusions found in EZ33A and ZH62A[1] magnesium alloy castings at the request of a foundry which produces light alloy castings mainly for the aircraft industry. Radiographic inspection of certain castings revealed the presence of two of the types of defects to be described, and uncertainty as to the nature and effects of the inclusions had resulted in the rejection of a number of pieces.

Inclusions of the first type were found only to a small extent in small and medium sized castings, and usually occurred in pieces weighing several hundred pounds before fettling (cleaning). They were frequently found near drag surfaces of the castings and in the vicinity of gates.

Inclusions of the second type were found in castings of all sizes, and were not limited to particular regions of the castings. Their appearance in radiographs differed from that of the Type 1 inclusions, but was similar to that of the Type 3 inclusions. Type 3 inclusions were included in the investigation mainly to make clear the differences in their composition and origin from Type 2 inclusions. They are only likely to be encountered in castings in which exothermic compounds have been employed.

PREVIOUS WORK

A brief literature survey showed that Emley,[2] in the course of an investigation of magnesium alloys containing zirconium, had observed inclusions which he termed "ring nebulae" from their radiographic resemblance to photographs of this phenomenon. These inclusions were sometimes associated with lamellated constituents. He also noted other complex and lamellated inclusions, comprising zirconium-silicon compounds and Mg_2Si, which were found in some cases to be caused by reaction of the alloys with a boric acid-French chalk ($3MgO \cdot 4SiO_2 \cdot H_2O$) mold dressing. In other cases these inclusions may have been caused by reaction with loose particles of molding sand.

In a recent paper Bergstrom and Bassett[3] describe defects in HK31A alloy castings which are evidently similar to the Type 1 inclusions. Although it is believed that the mechanism proposed in the paper for the formation of the inclusions is incorrect, the paper gives interesting information regarding their effects on room and elevated temperature tensile properties. The results were summarized by Bergstrom and Bassett as follows:

> "The condition of spherical and angular segregation has the effect of reducing ultimate tensile strength and per cent elongation at both room and elevated temperature. Room temperature testing of specimens with heavy segregation showed an average loss in ultimate tensile strength of 15 per cent, and a loss in per cent elongation of 37 per cent. The average 500 F ultimate tensile strength and elongation values of all specimens with spherical and angular type segregation were found to be 7 and 58 per cent, respectively, lower than observed in the normal samples."

The angular segregations mentioned above were not observed in the present work.

TYPE 1 INCLUSIONS

Radiographic Examination

The appearance of a typical group of the inclusions is shown in Fig. 1 which is an enlargement from radiographs taken in two perpendicular directions of part of an EZ33A alloy casting. The upper print shows the concentration of the inclusions near the drag surface of the casting. Comparison of the two views shows that the defects are roughly spherical.

It will be seen from Fig. 1 that the boundary of each inclusion appears to be a shell which is comparatively opaque to x-rays, while the center of the inclusion is somewhat less opaque to x-rays than the bulk of the alloy. The inclusions appeared to be similar to those described by Emley.[2]

Visual Examination

Defects near the drag surfaces of EZ33A and ZH62A alloy castings were revealed by grinding off a small amount of the surface metal.

Each defect was visible to the unaided eye as a black speck surrounded by a roughly circular, light-

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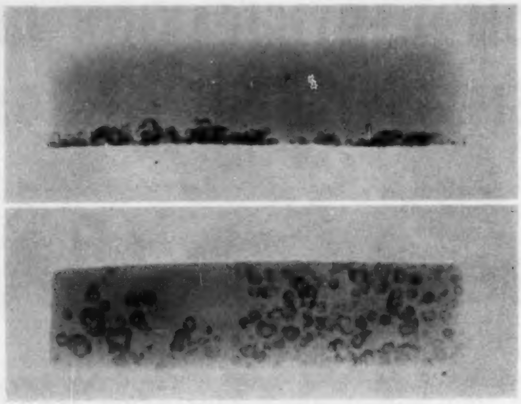


Fig. 1 — Radiographs taken in two perpendicular directions of a section of an EZ33A alloy casting. The shape and distribution of the inclusions are shown. The lower edge of the upper illustration is the drag surface of the casting. 2×.

colored zone bounded by a darker ring. Figure 2 shows these features at low magnification. At higher magnifications the defects were usually seen to contain one or more transparent crystalline particles associated with colonies of eutectic-like structure (Figs. 3 and 4). The boundary of the light-colored zone was seen to consist of a ring of particles.

Early in the investigation the appearance of the transparent crystalline particles suggested that they were the remains of sand grains which had reacted with the melts, and this was supported by the observations of Emley.[2]

Preparation of Synthetic Inclusions

In order to obtain rapid confirmation that silica sand particles were responsible for the inclusions, quartz crystals were added to small melts of pure magnesium and various magnesium alloys. The metal was kept molten and in contact with the quartz (without stirring) for a tew minutes and then slowly cooled. Examination of sections from these melts showed structures exactly analogous to those of the inclusions.

Pure magnesium reacted to give the characteristic eutectic-like structure found in the original specimens, but the boundary of the affected zone was not marked by a band of particles as in the original cases. The inclusions in pure magnesium were denser to x-rays than the matrix (probably owing to the low x-ray density of pure magnesium) and there was no opaque shell.

Quartz crystals reacted with K1A, (Mg-0.6 per cent Zr alloy), HZ32A, EZ33A and ZH62A alloys gave the structures shown in Figs. 7 to 9. These are similar to the original defects such as are shown in Figs. 3 to 6. The radiograph of a synthetic inclusion in HZ32A alloy showed the presence of an opaque shell similar to that found in the original inclusions.

Identification of Reaction Products

Metallographic Examination. Examination of sections of the original and the synthetic inclusions (Figs. 3-9) showed that the eutectic-like structure associated with the silica particles was made up of two phases which usually occurred in the form of alternate, parallel lamellas, but sometimes in more complex patterns.

One set of lamellas was blue-grey and the other brown. Farther from the silica crystal the blue-grey constituent tended to form massive crystals, and its place between the brown lamellas was taken by magnesium solid solution. The appearance of the blue-grey constitutent suggested that it was magnesium silicide (Mg_2Si). The brown lamellas tended to break away from the immediate boundary of the silica particle in the form of islands or colonies. Presumably, these lamellas are MgO from the reaction

$$4\,Mg + SiO_2 \rightarrow Mg_2\,Si + 2\,MgO$$

The identity of the band of particles which made up the boundary of the reaction zone in the original, and in the synthetic inclusions (except those in pure magnesium), could not be determined by metallographic examination.

X-Ray Diffraction Examination. A sample from an EZ33A alloy casting, which was shown to contain inclusions by radiographic examination, was dissolved in dilute hydrochloric acid and the insoluble residue filtered and dried. This residue was seen to contain a number of small transparent crystalline particles, and these were removed. Analysis by x-ray diffraction showed them to be α-quartz, which would be consistant with their being the remains of entrained sand grains.

Owing to the small size of the inclusions, direct identification by x-ray diffraction, in situ, was difficult and revealed only magnesium and magnesium oxide. In order to obtain a workable amount of reaction products a large piece of quartz was immersed for about 15 min in a small volume of molten magnesium. A sample taken from the large amounts of reaction products thus obtained was shown to contain, in addition to unreacted silica and magnesium, magnesium oxide and magnesium silicide (Mg_2Si).

Spectrographic Analysis. A large synthetic inclusion in HZ32A alloy was polished and a microvolume traverse[4] was made across it. In this spectro-

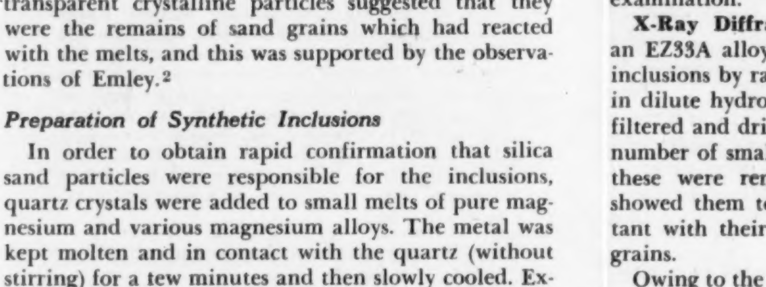


Fig. 2 — Inclusions near the drag surface of part of a ZH62A alloy casting. Unetched. 7×.

graphic analysis technique a small diameter spark is moved across the specimen to be analyzed (in this case an inclusion) at a known constant speed, and the resultant spectrum is recorded on a plate which is also moving at a known constant speed. Variations in concentration of elements in the specimen result in variations in intensity of the spectral lines recorded on the plate.

The intensities of certain lines for silicon, zirconium, zinc and thorium (Si 2881, Zr 3438, Zn3345 and Th 2978) were measured. Using the magnesium line 2781 as a standard, the intensity ratios of zirconium, zinc and thorium to magnesium were calculated using the element/magnesium ratio in the unreacted alloy as unity. As there was no silicon in the matrix, the silicon/magnesium ratio about 1 mm inside the reaction zone of the inclusion was taken as unity. The results were plotted against distance traversed, and are shown in Fig. 10.

It will be seen that marked segregation of zirconium and thorium has occurred, which has resulted in a high concentration of these elements at the boundary of the inclusion. The concentration of silicon begins to rise immediately inside the inclusion. There is some evidence that the zinc is segregated, but this is less definite than in the case of the other elements.

In the curves for zinc, zirconium and thorium the troughs between the peaks occur because the central region of the inclusion is occupied by a silica particle.

The results of spectrographic analysis strongly suggested that the shell round the inclusions (which was opaque to x-rays) was composed of compounds of zirconium, thorium and possibly zinc, with silicon and magnesium. The results also confirmed that the silica particles had reacted with the molten alloy, although they did not, of course, indicate the precise nature of the reaction products.

TYPE 2 AND TYPE 3 INCLUSIONS

As mentioned previously, the Type 2 inclusions were observed in radiographs of commercial EZ33A alloy castings. Type 3 inclusions were found near risers in which exothermic sleeves had been used.

Radiographic Examination

In radiographs, inclusions of Types 2 and 3 were similar. They both appeared as clouds of various dimensions and shapes, and were both denser to x-rays than the matrix. Figure 11 shows inclusion clouds in a production EZ33A casting. Figure 12 shows Type 3 inclusions found in a riser having an exothermic sleeve (EZ33A alloy).

Visual and Metallographic Examination

Unlike the Type 1 inclusions, those of Types 2 and 3 could not be seen by the unaided eye. In polished sections at high magnification the inclusion clouds were shown to be made up of particles (Figs. 13 and 14). It will be seen that there is a close similarity between the two types of inclusions.

Spectrographic Examination

Samples of Type 2 and Type 3 inclusions were examined by the spectrographic microvolume traverse technique outlined earlier.

The results (shown in Figs. 15 and 16) are plotted

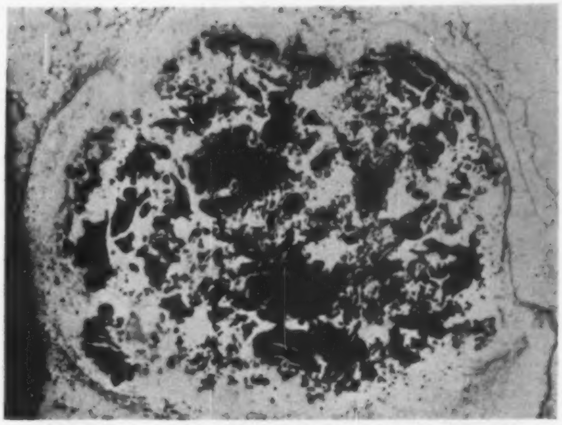


Fig. 3 — Inclusions in EZ33A alloy casting. The dark areas are the transparent crystalline material (SiO_2). The dark gray areas are the lamellar constituents, and the boundary zone consists of small particles which are probably compounds of silicon and zirconium and rare earth metals. Unetched. 50×.

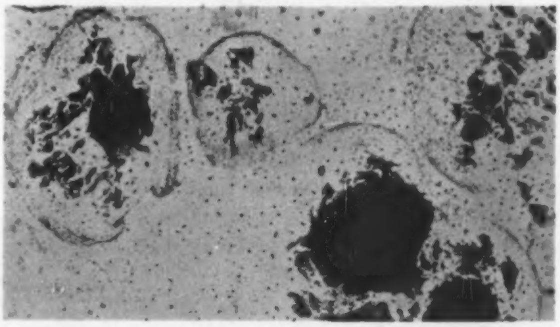


Fig. 4 — Inclusions in ZH62A alloy casting. The silica particles are gray (transparent in the original) and are surrounded by dark lamellar regions (lamellas not resolved, in most cases). The lighter lamellar constituent (brown in the original) occurs farther from the silica particles, and in some cases has broken away in the form of islands. Unetched. 50×.

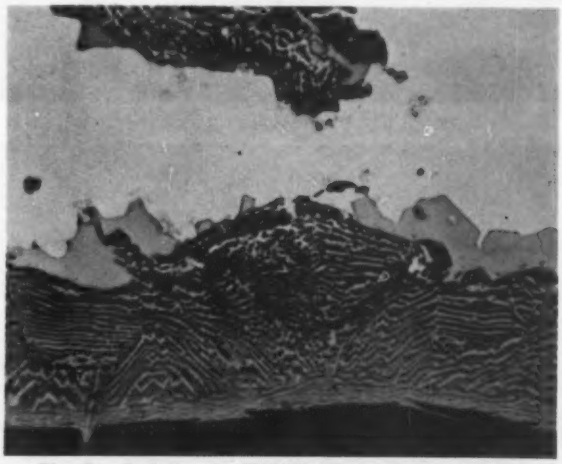


Fig. 5 — Inclusion in ZH62A alloy casting at higher magnification to show formation of lamellas at the surface of the SiO_2 crystal (black). The dark lamellas (brown in the original) are thought to be MgO, and the light gray lamellas (bluish gray in the original) are thought to be Mg_2Si. Farther from the SiO_2 crystal (light gray) massive Mg_2Si crystals have formed and islands of MgO lamellas are breaking away. Unetched. 750×.

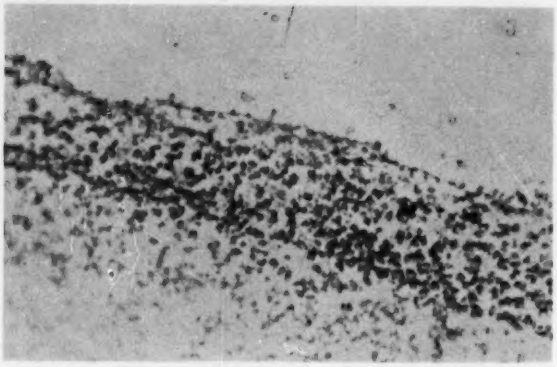


Fig. 6 — Part of the boundary region of an inclusion in a ZH62A alloy casting showing particles (probably compounds of silicon and thorium and zirconium). Unetched. 750×.

as intensity ratios iron/magnesium and aluminum/magnesium, respectively. They could not be conveniently expressed as concentration ratios relative to the concentration ratio in the matrix, because the intensity of the iron and aluminum lines in the matrix was too low.

In the Type 2 inclusions the only elements found at levels above those in the matrix were iron and zirconium. Figure 15 shows the variations in the intensity ratios of iron/magnesium and zirconium/magnesium, and it will be seen that there is a distinct parallelism between the two curves.

From this evidence it seemed probable that the Type 2 inclusions were particles of an iron-zirconium compound. To confirm this, a zinc-5 per cent iron alloy was added to a melt of EZ33A alloy. Examination of a polished section showed particles similar to those found in the original specimen. The radiographic appearance was also similar to that of the original sample mentioned above.

The results of the microvolume traverse on a group of Type 3 inclusions are shown in Fig. 16. In this case, aluminum and zirconium were the only segregated elements. Although the curves for the two elements did not correspond as closely as in the case of the Type 2 inclusions, it seemed reasonable to conclude that the Type 3 inclusions were particles of an aluminum-zirconium compound.

DISCUSSION AND CONCLUSIONS

Type 1 Inclusions

The experiments and examination described, taken with the observations of Emley,[2] led to the conclusion that the inclusions were caused by entrained sand grains which had reacted with the melt. These probably came from those parts of the mold surface over which there was a considerable flow of metal, for ex-

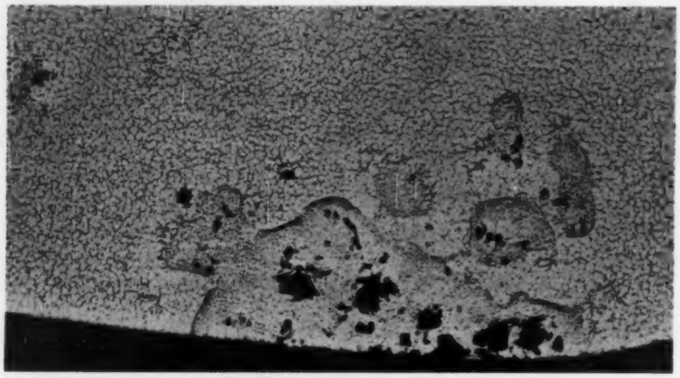


Fig. 7 — Unetched. 12×.

Figs. 7-9 — "Synthetic" inclusion HZ32A alloy. Figure 8 (c.f. Fig. 5) shows the formation of lamellas at the surface of the quartz crystal, and Fig. 9 (c.f. Fig. 6) shows particles in the boundary region.

Fig. 8 — Unetched. 750×.

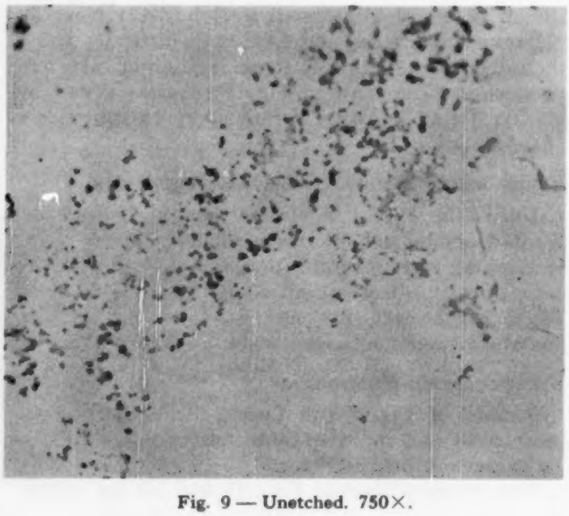
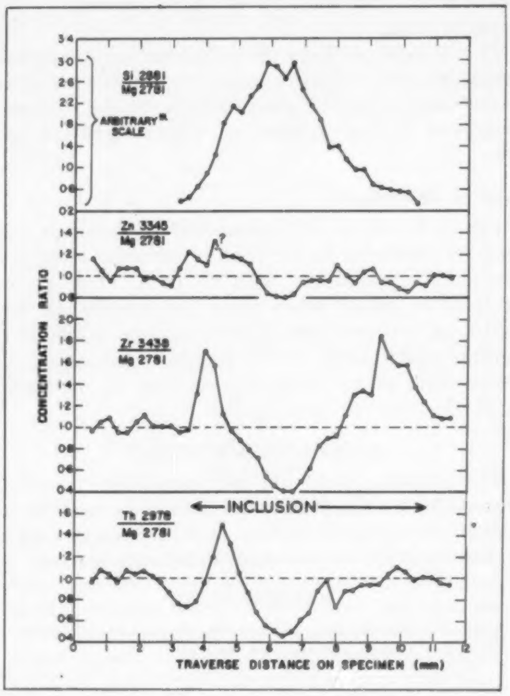


Fig. 9 — Unetched. 750×.



*The Magnesium line, 2781, is used as a standard, calculating the zirconium, zinc and thorium ratios to magnesium using the element/magnesium ratio in the unreacted alloy as unity.

Fig. 10 — Curves to show the variation in concentration of silicon, zinc, zirconium and thorium across a "synthetic" inclusion in HZ32A alloy. Determinations were made by spectrographic microvolume traverse.

ample the gating system. As noted in the introduction, the inclusions were observed mainly in large castings in which a large volume of metal would pass into the mold. Another factor which might lead to loose particles of sand in the mold is disturbance of the mold after it is made such as, for example, during the placing of steel wool for skim gates.

Much of the work reported above was done to determine the nature of the products of the reaction of silica with the melt. The probable initial reaction is:

$$4\ Mg + SiO_2 \rightarrow 2\ MgO + Mg_2Si$$

The Mg_2Si and MgO are formed in alternate layers at the silica/melt interface. Farther from the silica particle the Mg_2Si forms massive crystals. The MgO lamellas remain in islands, the individual layers being separated by magnesium solid solution.

In alloys containing zirconium, zirconium-silicon compounds form a shell around the inclusions. This shell, which is relatively opaque to x-rays, gives the inclusions their characteristic appearance in radiographs. Rare earths and thorium also seem to be segregated in the outer shell, possibly in the form of compounds with silicon.

As far as is known, the sand inclusions surrounded by reaction products have only been observed, in practice, in castings made from alloys containing zirconium. This may be because castings which are subject

Fig. 11 — Radiograph of Type 2 inclusions in a commercial EZ33A casting (actual size).

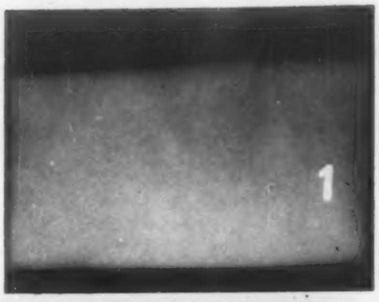


Fig. 12 — Radiograph of Type 3 inclusions in the riser of an EZ33A casting. An exothermic sleeve was used in the riser (actual size).

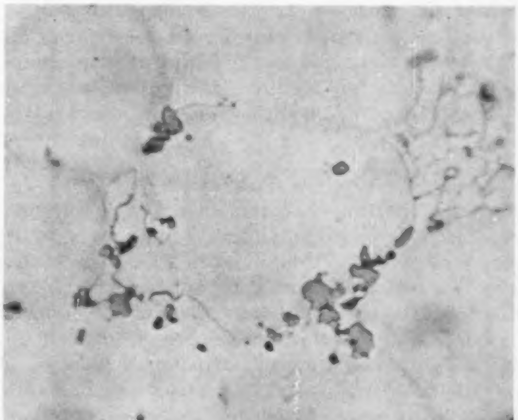


Fig. 13 — Type 2 inclusions in an EZ33A alloy casting. Unetched. 1000×.

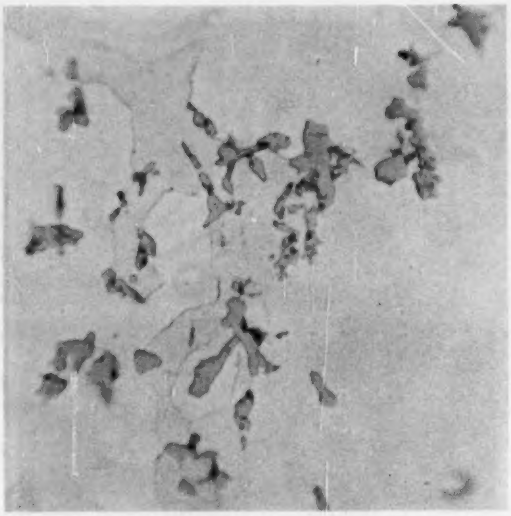


Fig. 14 — Type 3 inclusions in an EZ33A alloy casting. Unetched. 1000×.

to radiographic examination, and which are large enough to produce the necessary sand wash conditions, are normally made in alloys containing zirconium; or possibly because the inclusions are less obvious in radiographs when the opaque shell of zirconium (and possibly thorium and rare earth) compounds is not present. It should be noted that, under certain conditions, similar inclusions could occur in any magnesium alloy.

Type 2 Inclusions

Type 2 inclusions are thought to be particles of an iron-zirconium compound. The source of the iron was not determined but it must presumably be introduced during or after pouring, because if it were introduced in the crucible the iron-zirconium particles would have time to settle to the bottom of the melt. One possible source is the steel wool filters which are used in some gating systems.

The effects of Type 2 inclusions on mechanical properties were not investigated. An indirect effect, in severe cases, would be the reduction of the zirconium content of the melt leading to coarsening of the grain size.

Type 3 Inclusions

Type 3 inclusions are probably aluminum-zirconium particles produced by the reaction of aluminum (from exothermic compounds) with the melt. They are only likely to be found when these compounds are used. Again, in extreme cases, there could be a loss of zirconium which might result in grain coarsening. The direct effect of the Type 3 inclusions on mechanical properties was not investigated.

ACKNOWLEDGMENT

The authors would like to express their thanks to Light Alloys Ltd., Haley, Ont., Canada, and in particular Mr. L. G. Day, Fdy. Mgr., for suggesting the problem and for cooperation in the investigation.

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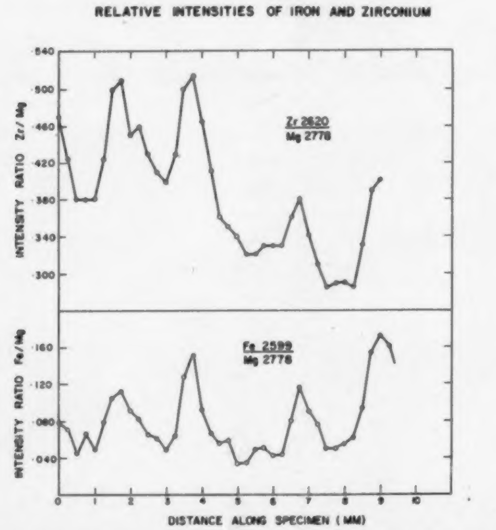

Fig. 15 — Results of a microvolume traverse across a region of an EZ33A alloy casting containing Type 2 (iron-rich) inclusions. Note the close parallelism of the iron and zirconium curves.

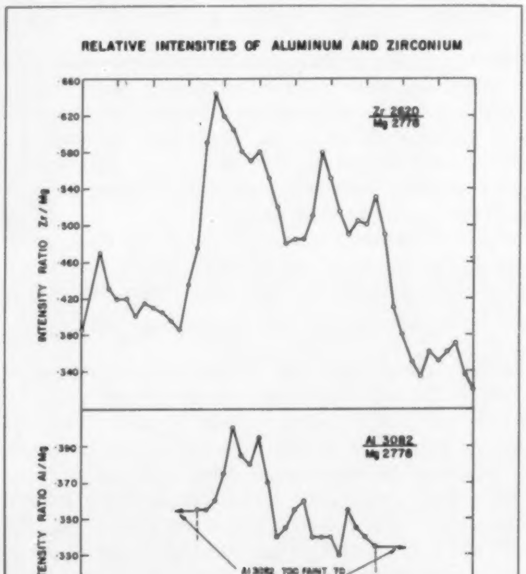

Fig. 16 — Results of a microvolume traverse across a region of an EZ33A alloy casting containing Type 3 inclusions. There is a definite relationship between the aluminum and zirconium curves, but this is less pronounced than for the Type 2 curves.

CONTROLLING COSTS OF FOUNDRY OPERATIONS

by K. T. Rinderle

ABSTRACT

Management should inform its foremen of the goals of a cost control system in a positive manner, and in a language understandable from their point of view. Only those costs which are the foreman's responsibility should be relegated to him. These expenses are collected over a sufficient period of time, and a budget allowance set. A running graph showing the extent the actual costs approached the set goals is made from data collected. These charts can be put to various uses, such as at meetings, as long as the information can be related to the goals in operation. This overall approach to the problem of cost control, and how it can be related to the individual operations in the foundry, is presented by the author.

INTRODUCTION

Millions of people go to work as employees to earn a living; to earn a return on the investment of their time, talents and efforts. They know that they will receive a guaranteed minimum return for each hour they work on their job.

Some people invest in a business which creates such employment to earn a living; to earn a return on the investment of their savings. However, they are not guaranteed a minimum of return for each hour the employees work. They receive a return only if the costs of operating the business average less than what the business receives in return from its customers.

Of course, they do not invest unless it has been shown that such a return is likely.

Thus, the people who invest in the business must rely on the people for whom they furnish employment to maintain costs at a level which yields a return from the customers. If costs are not so maintained the business fails, and employees as well as investors lose their source of income.

COST MAINTAINING RESPONSIBILITY

This is putting it simply. The point is that it takes people to create and to continue a business. It is not only a responsibility but a necessity that all of the people involved in the operation of a business take an active interest and part in maintaining costs at a level that will yield a return.

Instilling such an understanding and active interest on the part of all those in a business is the great challenge and opportunity of management.

Consider the impact on the foundry industry today if the approach of all those in a particular business were the putting forth of their best and conscientious efforts. This is no Utopian idea, nor is it an impossible goal. There are plants where this is being realized.

NEED FOR COST SYSTEM

Today's approach to controlling costs in the foundry can and must be through those on the production line where the costs are being created, at the minute they are being created.

To accomplish this a Cost Control System is needed. It is not the structure or the mechanics of this system that counts, it is the philosophy of the system that determines its success. A system, as such, cannot control costs; only people can. The key is to build a system in terms of, and in a manner to inspire, the people relied on to make it work.

Management many times is trapped into assuming the job of managing, directing, disciplining and controlling; they believe they are running the business. Management is wrong if they do not realize it is their responsibility to guide, to lead and to set up conditions whereby all those in the business feel they have a personal responsibility and opportunity to take an active part in running it.

MANAGEMENT'S RESPONSIBILITY

Anything from a modest do-it-yourself cost control system to the most comprehensive and professional system can be used in the foundry. It is up to management to bridge the gap between the system and its application—the actual controlling of costs in the plant.

A "system" is a dead, static thing. It is usually in the form of a statistical writeup including exhibits, forms and impressive functional, organizational and flow charts. The controlling of costs in the foundry can be a success if its book is in terms of the people who will live it, and if it is taught in their terms with a positive, encouraging approach. Men resent controls, but aspire to understandable and attainable goals.

Managers say, "Certainly, we resent controls and we

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aspire to goals; but whether they resent it or not, the foremen's and operators' costs must be controlled if we are to reach our profit goal." True. However, it would be better to say, "One of our goals is to successfully show the way, and help the foremen and operators keep their costs under control."

PRODUCTION LINE CONTROL

Management must define the costs which are actually within the power of the foremen and operators to control on the production line. It must be realized that there can be times when a foreman or all foremen are doing a splendid job of controlling costs that are within their power to control, but the company may be experiencing a loss.

Management's approach is negative and not conducive to continuing good morale if, during such times, the trouble appears to be laid at the foremen's doorsteps; or, if, during good times, credit is given only to superlative sales or administration efforts.

Foremen are generally aware of the effects of volume variance on the company's constant costs, of terms like depreciation and burdens, of the pressures resulting from increasing operators' wages and benefits and of the rigors of competition for work during recessions. These and similar terms and pressures occur in a larger sphere around and beyond the boundaries of their direct responsibilities or abilities to control.

It may be wise to inform the company's foremen of these management cost factors to the extent that foremen are trained as department managers. Such factors cannot be included in a system for controlling costs in the shop as they are not controllable by the men in the shop, and are in large measure beyond their understanding. Inclusion of constant and semi-constant costs in a control system would put these men on the defensive.

FOREMAN'S RESPONSIBILITY

The factors that should be included in a foreman's responsibilities for control are:

1) Control of the production of his department's product.
2) Control of the quality of that product.
3) Control of his department's costs associated and reasonably variable with the production of that product.

Flexible Costing System

These are terms of a standard flexible budget costing system. In such a system there is an opportunity for control of "in foundry" costs. So, when a department is mentioned here, it is thought of as a Cost Center. When a department's product is mentioned, the words "process" and "service" are included.

A foreman usually thinks of his product as numbers of molds of different part number castings, cores for different jobs, pounds of metal converted to a certain analysis, castings chipped and ground, etc. In fact, most of us think of the operation in terms of castings or parts or treatments of castings.

For this reason, when shop people are spoken to in terms of Quality Control and Production Control there is no problem of communication. These are real, functional and immediate terms for them as are terms of understandable fixed units of measurement as cold shuts, shifts, pounds, carbon contents, number of cores or molds, per cent scrap, etc.

TIMELESS MEASUREMENT UNITS

These units of quality and production measurement are timeless. Historical, present or projected data require no interpretation, qualification or other mental gymnastics for clear understanding. They can readily be seen, reported and charted. They are of the substance, and familiar media, of the life and work of the foremen and operators. For these reasons, the maintenance and improvement of quality and production control systems are not difficult to accomplish. They are in terms of the people affected by them, and the results are visual and immediate.

It has been demonstrated over and over again in foundries that these systems can be a success when they are applied in the spirit of striving for attainable goals. Foundrymen are motivated first by pride of accomlishment. American men have created the high standard of living through an inner aggressive competitive drive to make a good thing better.

POSITIVE APPROACH

Shop Concerns

This is the positive approach, the challenge, the personal and attainable target. Let us consider these words "personal" and "attainable." The melter is personally concerned most with the quality and quantity of his department's product, metal. The core foreman is concerned most with cores. The welding foreman is concerned most with repairs. They strive for quality and production goals directly related to those personal concerns when those goals are understandable and reasonably attainable with the tools and conditions of their departments.

This reality of the continuing and spirited striving for improvement of quality and production in foundries is something in which the shop takes a great deal of pride. Quality control and production control systems are successful working tools of the technical and operating men.

Management's Cost System

Management's cost control system can be such a tool if it is founded on the same principles and philosophies.

Profit is management's product. Profit, if it is a product, is a result. A result can be planned. Previously it was said that people invest in a business when it has been shown that a return is likely or planned. This means, the return will occur if nothing goes wrong with the plans or, as in the management function, if manufacturing costs as planned are not exceeded.

This brings management's goal one step closer to the people in the shop—the holding under control of planned manufacturing costs. What does this mean? How can we express this portion of management's goals as understandable, attainable and personal goals for the foremen?

A Different Approach

What may be a different approach may be the key. Stand in a shipping department and watch a day's production of castings being grouped and shipped. In any foundry, and especially a job shop, this collection of many different sizes, shapes and analyses of castings being produced for a number of different customers could convince anyone that business is tremendously complex. Most everyone could consider it impossible to even know, much less control, the manufacturing costs of producing each individual casting in such a collection.

Do not look at it in this way. Look at the castings as one assembly of the basic products of the plant's departments—pounds of converted metal as one lump, units of core making, units of molding and units of cleaning as one summary collection of each. If there are ten production departments, look at them as totals of ten different items.

DEPARTMENT MEASUREMENTS

Each foundry department produces a basic casting ingredient. Each ingredient can be defined and expressed as a unit of measure of the function of the department. In melting, it can be pounds converted; in the sand department, it can be tons of core material prepared; in a production department (as squeezer molding), it can be standard time units of molding. For labor, standard time units can be used as measured by standard data.

These units may also be direct hours, or any other measure for which the method of measurement is constant. That is, the unit of measure must be timeless —a direct hour was, is and will always be 60 min; a standard hour is always 60 min; a pound of metal a pound; a ton a ton; etc.

This requirement is important. Past present and future controls on such units remain in focus and retain their usefulness. If the units were expressed in dollars, data based on such monetary units would have to be converted or interpreted in some manner to a control period. Monetary units cannot be used to furnish a foreman a continuous, direct, easily understood measurement of his efforts to control his department's costs.

Analysis in terms of money is a function of management, and is not within the scope of the foreman's responsibility to compare over periods of time.

JOB ESTIMATION

Let us consider this approach from the other end, starting with the blueprint of a casting. The job is estimated first in terms of amounts of the units of measurement of departments; the usage of as much departmental production as is practicable. However, how many different departmental units of measurement are used in estimating the job? That is the number of different units assembled in a day's shipments.

Should the job be received with an approval of the samples, and prove out production methods, the actual number of units to be allowed each department involved to produce one casting is then determined. These are the casting's "predetermined unit allowances."

Consider the predetermined units allowed for squeeze molding a one cavity mold on one pattern. These units will be joined with predetermined units allowed for squeeze molding other part numbers produced in the department. The total of such predetermined allowed units per hour, day, week or month will be the measure of the salable effort of the department for those periods. It makes no difference what particular patterns the total units came from so far as controlling departmental cost of each and all of those units is concerned.

PREDETERMINED ALLOWANCES

Thinking in terms of a department's predetermined unit allowances rather than individual patterns are correct, direct and understandable measures of the department's work. This is the simple approach to controlling the department's variable costs. Cost problems are experienced by departmental type or class of work rather than by individual pattern numbers.

Once it has been decided to compare costs in a department according to production of its predetermined units of measurement, the rest is comparatively simple. For each department, expenses are defined as reasonably controllable by that department's supervision. This should vary directly with the production of its units of measurement.

Cost Control Terms

Express these expenses in "timeless" terms. For example:

1) Labor in terms of actual hours classified as direct, setup, allowed, delay, overtime allowance or any other category it is felt necessary to control.
2) Services from other departments in terms of their unit of measurement as direct or standard hours.
3) Waste items as makeup and plus-predetermined allowances as actual hours.
4) Supplies in physical terms as much as practicable. Usually, this applies to major items like electrodes, large grinding wheels or cubic feet of oxygen. Other supplies included may have to be grouped and expressed in terms of dollars. It is not suggested that shovels be listed as shovels, or parting bags as parting bags.

The important thing is to keep these expressed in the foreman's everyday language.

BUDGET ALLOWANCE

Collect these expenses over a sufficient period of time, and then, with the foremen participating, set up a budget allowance of each such expense per the department's unit of measurement. These budget al-

lowances are then his understandable and attainable goals. These goals rise and fall directly with the level of the department's salable production.

For any chosen period, multiply the predetermined allowed units produced by the budgeted allwance per such unit for each expense and you have the goals. By daily reports, collect the actual usages for each expense, update them for the period, and compare the actual totals to their budgeted goals. Any differences are usually called plus or minus variances. The extent to which the actual costs approached the goals, variances or any other function explored may be reduced directly to always comparable percentages. It is then simple to chart these percentages on a running graph.

COST GRAPHS

Thus, a foreman's accomplishment in cost control has been related pictorially, and he can see his attainment of cost goals on the graphs as realistically as he can see his success in the quality production of his department's product. Of equal importance is the fact he understands and trusts these goals. They are controllable by him, expressed in his language and he helped set the budgets. He knows the goals are a fair and true measure of his cost control efforts.

Cost Graph Uses

Extensions of his cost graphs can be almost immediate. They can be made by the day at the beginning of a program, although normally they would be made at least by each Tuesday for the preceding week. If the graphed lines indicate "on the target" for an expense, the foreman is automatically at the predetermined cost. To that extent he has guaranteed a return on that portion of the cost of all work performed in his department. If the lines are over target, he is losing; and if under target, he is gaining. Such charts have been applied by the author to a single occupation, and the operators have responded enthusiastically to bring the lines for waste expenses as "delay" onto target.

Another use for these occupational and departmental charts the author has made is in weekly meetings with a Union Shop Committee. As a group, they became as effective as a foreman in cutting waste and improving performance and morale in the plant. There is always that fascination of striving for attainable goals; this is the real motivation. Increased earnings usually follow as a result.

Departmental variances of like kind totalled horizontally will yield a consolidated overall picture for management.

This discussion has been only about cost control, but it can be seen how sensitively and quickly the charts will reflect and encourage cost reduction efforts.

COST OF SYSTEM

What about the cost of such a system? Expenses must be accurately defined, coded and collected in their own measure before they can be converted to money for payroll and accounting purposes. Draw them off sideways for the controls. Running the budgets, variances and graphs is clerical work, or most of it can be run off by mechanical means.

This system of cost definition, collection and graphing of actuals can be pictured as related to goals in operation. It takes patience, teaching and selling, but it is more than worth the effort. However, this is only the beginning. At this stage the plant is ready to benefit from the system's greatest potential – individual goals for individual operators.

The concept of the approach has been based on timeless units as the measure of a department's salable production and cost of manufacturing. The department's total production of units is the collection of individually set, or standard predetermined, allowances of these items for each piece of each casting part number worked on. In other words, the measure has been carried to each direct operator's work when estimates have been made, and then the actual allowance when the job was "gelled." Thus, the production goal for each experienced operator to attain at a normal day rated work pace has been set. Cost goals have been brought down to the individual jobs of the individual operators.

OPERATORS' GOALS

Each operator is guaranteed a minimum return per hour worked. This sets the operator cost or budget per piece when he hits his day rate goal of units. He is credited with all the good units he produced while working at or above normal pace; he has a moving goal. Thus, as he may increase his effort beyond the normal pace, he increases his production of units while the salable unit cost for his work remains the same.

Such performance of the operator is measured in terms of the relationship of the actual units he produces to the units allowed per actual hour of an experienced operator at a normal day-rated pace. If the performance is 100 per cent, he is "on target." Operator performances should be graphed individually and grouped by occupations as goals by the day. Cost control-wise, the recording and graphing of such performances should be graphed individually and group formance must be kept and thought of in terms of unit and clock time measurements. This keeps them comparable over all periods of time.

However, should management decide to convert over 100 per cent performance to additional pay for the operator, the effect on his performance and resulting controlling of costs is obvious.

CONCLUSION

The above approach to the controlling of costs in the foundry will not result in people coming on their jobs just to "make a living." It is one that will result in people coming to their jobs that present them with understandable, attainable and immediate goals. Goals that present an atmosphere that encourages people to work with the zest of making a good thing better. Such an atmosphere can only result in greater earnings for the employees, lower prices for customers and an assured return for the investors who make jobs possible.

PARASHRINKAGE PHENOMENA—VEINING, METAL PENETRATION, SCABBING, HOT TEARING

by D. C. Williams

ABSTRACT

Hot spots are composed of two parts in several surface-type casting defects — a volume of molded sand, and a volume of liquid at the thermal center. These are separated from each other by the mold-metal interface. Within the thermal center, shrinkage develops. Shrinkage derivatives, veining, metal penetration and possibly scabbing, may develop because of unsatisfactory melt quality within the thermal center. Separating the thermal center from the hot spot location involves altering of isothermal lines during metal solidification.

INTRODUCTION

In recent literature discussing surface casting defects attributable to the malperformance of compacted sand mixtures, there will be found references to volumes of molded sand masses at re-entrant angle locations designated as "hot spots."

It is proposed in the following to enlarge the scope of the hot spot by showing that it is composed of two immediately adjacent parts.

Part one. A restricted volume of sand mass whose temperature level has been raised above that of the surrounding masses and such masses may occur anywhere on a mold-metal interface.

Part two. The thermal center of a solidifying mass in a casting section. The thermal center of a casting section is the last portion of the section to solidify.

It is only when this thermal center (part two) is manipulated, naturally or intentionally, so that it takes up a position adjacent to the mold-metal interface, that this center constitutes a part of the hot spot. Figure 1 is a schematic representation wherein the enclosed areas depict what in a three dimensional situation are the volume portions of the hot spot.

Brandt, Bishop and Pellini[1] provide information in their Figs. 4 and 10, which when combined illustrate for their "L" shape configuration the natural manipulation of the thermal center toward a location adjacent to the mold-metal interface. It will be noted, in their case, that the hot spot situation could not have developed until solidification had been proceeding for at least 50 min. Figure 2 (this paper) depicts the isotherms they obtained within the molded mass at 50 min, and the solid-liquid isotherm existing at the same time in the casting section to illustrate the enlarged scope of the hot spot.

THERMAL CENTER

Due to selective freezing (segregation) within alloys the composition of the molten material remaining within the thermal center will vary from that material which has solidified. Also due to segregation, soluble gases and reactants for gas formation can be moved into the thermal center as well as finely divided slag particles, oxides, etc. The accumulation of these nonmetallic materials in the remaining liquid of the thermal center may attain sufficient concentration to produce within that liquid mass a "melt quality"[2] of undesirable level – this regardless that in the ladle the melt quality may have seemed satisfactory.

The natural defect to develop at the thermal center, regardless of its location, is shrinkage which will be manifested in one of many ways. When the thermal center is manipulated into a location adjacent to the mold-metal interface at a re-entrant angle shrinkage will develop in two ways, as schematically illustrated in Fig. 3a and 3b. Many times the phenomenon (Fig. 3a) is diagnosed as a hot tear. If the melt quality of thermal center liquid has deteriorated to the level at which gases can be generated or solidifying constituents markedly increase in volume, pressure will be developed within the remaining liquid.

LIQUID EXTRUSION

This forces an extrusion of liquid material into the void spaces of the immediately adjacent molded sand mass. This extruded material can produce the defects

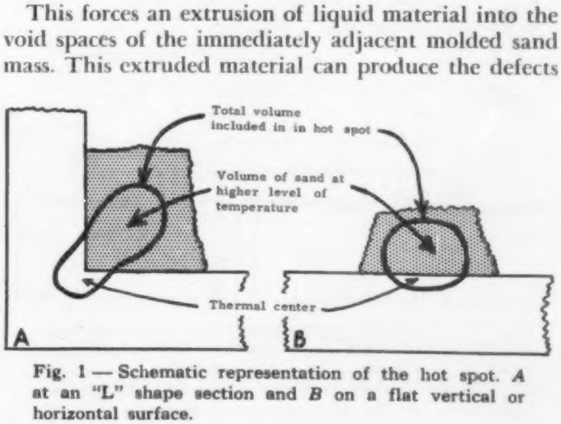

Fig. 1 — Schematic representation of the hot spot. *A* at an "L" shape section and *B* on a flat vertical or horizontal surface.

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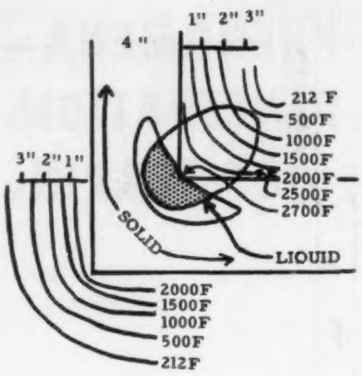

Fig. 2 — Development of a hot spot at an "L" shape section 50 min after pouring, using the data of Brandt, Bishop and Pellini.[1]

commonly known as either veining or penetration. Thus, one can make the claim that veining and metal penetration may be derivatives of shrinkage. The level of melt quality of the thermal center will be the deciding factor as to which defect will develop. Stated another way, had there been no metal penetration there may have been a shrinkage manifestation. The shrinkage occurrence (Fig. 3b) is sometimes diagnosed as some kind of a blow.

Actually the shape of the depression is that of incipient piping, and the melt quality level of the thermal center was satisfactory. However, had the melt quality level been unsatisfactory, veining or metal penetration would have developed. The elimination of defects at the indicated locations can be accomplished by manipulating the thermal center to some location in the interior of the casting section.

SURFACE SHRINKAGE

Shrinkage-type defects occur on horizontal, vertical, flat and curved surfaces such as schematically illustrated in Fig. 3c and 3d. A good illustration of surface shrinkage on curved surfaces will be found in the American Foundrymen's Society book ANALYSIS OF CASTING DEFECTS, 1st Edition, p. 4, Fig. 1.

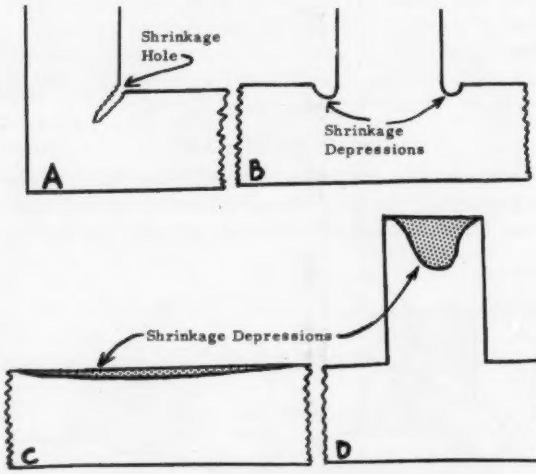

Fig. 3 — Schematic representation of shrinkage type defects at re-entrant angle locations and on flat surfaces. *A* is diagnosed as a hot tear; *B* as some kind of a blow; *C* and *D* as shrinkage-type defects on horizontal, vertical, flat and curved surfaces.

The depression illustrated in Fig. 3d is a manifestation of piping, the same as one observes in a properly functioning riser, but a poor melt quality in the thermal center of such a boss-like shape would give rise to veining or metal penetration. Figure 3c depicts the shrinkage depression spread out over a larger area. This type of depression is sometimes regarded as the result of gas pressure developed within the molded mass. However, if the melt quality of the thermal center adjacent to the mold-metal interface decreased to an unsatisfactory level liquid metal may be extruded into the molded sand producing veins, metal penetration, or possibly scab (commonly called the expansion type).

SCAB FORMATION

It is interesting to note the marked similarity between the shape of a shrinkage depression and the contour of the casting surface where a scab has developed. In addition, the defect, buckle, has a like similarity in shape to a shrinkage depression or piping. Therefore, we possibly can add scab formation to the list of derivatives of shrinkage, and scab formation can possibly be eliminated by manipulating the thermal center to a location within the casting.

Separating the thermal center from the hot spot location involves altering, not elimination, of isothermal lines during solidification. For castings of complex configuration considerable study may be required to satisfactorily alter the isotherms of solidification. Many procedures for such alteration are well known and, therefore, not a subject to be covered in this paper.

The development of sites of hot tearing is closely related to the thermal center location. Surface manifestation of hot tearing can be eliminated by a proper manipulation of the thermal center location.

There is one casting defect, rat tails, which so far has been a real problem for the author of this paper. To date no satisfactory explanation for this defect seems to be available.

CONCLUSION

The hot spot, site of several surface-type casting defects, is composed of two parts, namely, a volume of molded sand, and a volume of liquid at the thermal center, separated from each other by the mold-metal interface. Shrinkage develops naturally within a thermal center. Shrinkage derivatives, commonly known as veining, metal penetration and possibly scabbing, may develop due to unsatisfactory melt quality within the thermal center. If one of the derivatives did not develop, shrinkage would. Castings without shrinkage or one of its derivatives merely indicates the isothermal lines of solidification have been naturally or intentionally manipulated in such a manner so that the thermal center has been adequately separated from the mold-metal interface.

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CORROSION-FATIGUE IN TWO HOT WORK DIE STEELS

by D. N. Williams, M. L. Kohn, R. M. Evans and R. I. Jaffee

ABSTRACT

Two hot work die steels, H21 and H23, were examined by means of elevated temperature mechanical fatigue studies to determine the relative importance of oxidation and fatigue loading on corrosion-fatigue failures in die steels. It was found that sample life in the range of 1100 F to 1400 F was relatively independent of oxidation. Variations in heat treatments, test conditions or other material properties were found to affect sample life in direct proportion to their effect on the plastic strain imposed on the sample during cyclic loading. Sample life could be calculated by use of the equation:

$$N = \frac{1000}{(S)^2}$$

where N = sample life in cycles.
S = plastic strain in per cent imposed on the sample each half cycle.

INTRODUCTION

There are many environments in which materials are exposed to the combined action of both cyclic strain and oxidation. The accelerated fatigue process occasionally observed under these conditions is referred to as corrosion fatigue. Metal forging or casting dies, which are subjected in service to alternate heating and cooling in an oxidizing atmosphere, frequently develop a fine network of oxide-filled cracks on the surface which are believed to result from corrosion fatigue. These cracks, referred to as die or heat checks, can ultimately become large enough to require replacement of the die.

The present investigation was designed to examine the relative importance of the corrosion and the fatigue processes in corrosion-fatigue failures of hot work die steels. At the same time, the effects of variations of material properties, such as strength, resistance to tempering and oxidation resistance, upon the tendency for corrosion-fatigue failures were examined.

MATERIALS

Two hot work die steels were selected for use in this investigation, A.I.S.I.-S.A.E. types H21 and H23. The nominal compositions of these alloys are:

Alloy	Cr, %	W, %	C, %
H21	3½	9	0.35
H23	12	12	0.30

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The material was received in the hot worked and annealed condition. Some of the alloy was examined as received. The remainder was heat treated to give a high yield strength. The properties of the materials are given in Table 1. It is seen that the greatly superior strength at 75 F of heat treated H21 is rapidly lost as temperature is increased. At 1300 F, H23 is about equivalent to H21 in strength.

These two alloys were selected for use in this investigation principally because of their considerable difference in resistance to oxidation and tempering. These differences are illustrated graphically in Fig. 1. Oxidation data were obtained at 1100 F, 1200 F, 1300 F and 1400 F. At the lower temperatures, oxidation was negligible. At 1400 F (Fig. 1) H21 was considerably less oxidation resistant than H23. The alloy condition had little effect on oxidation resistance.

Tempering curves were obtained from the test samples by measuring the loss of hardness occurring during corrosion-fatigue testing. Hardness is plotted versus a tempering parameter permitting both time and temperature of tempering to be included on the graph. Figure 1 also shows that H23 was more resistant to tempering than H21. To get equivalent softening in H23, a temperature roughly 200 F higher is required. H21, for example, first shows softening after 1 hr at 1180 F, while H23 first shows softening after 1 hr at 1380 F.

EXPERIMENTAL PROCEDURE

Although cyclic strain is generally imposed on die steels by thermal expansion and contraction, it is almost impossible using thermally induced strains to separate the effects of cyclic strain from those of oxidation. Therefore, mechanical strain imposed at constant temperature was substituted for thermally in-

TABLE 1 — PROPERTIES OF TWO HOT WORK DIE STEELS

Alloy	Condition	Hardness (Rockwell Scales)	0.2% Offset Yield Strength, psi 75 F	1300 F
H21	Annealed	RB87	60,000	16,000
	Quenched and tempered[a]	RC50	230,000	55,000
H23	Annealed	RB95	—	18,000
	Quenched and tempered[b]	RC42	114,000	53,000

[a] Air cooled from 2150 F and triple tempered between 1100 and 1200 F.

[b] Oil quenched from 2300 F and triple tempered between 1000 and 1100 F.

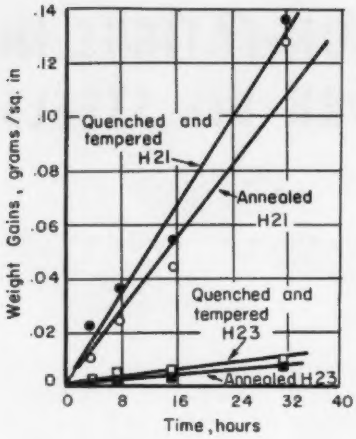
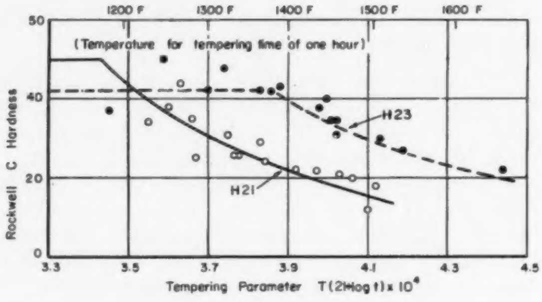


Fig. 1 — Comparison of the oxidation and tempering behavior of H21 and H23 die steels. Graph at left shows oxidation loss at 1400 F; graph below shows resistance to softening.



t = time, hr; T = temp., R.

duced cyclic strain to permit a more exact study of corrosion-fatigue in hot-work die steels. Examination of the fatigue samples after testing indicated that mechanical strain at elevated temperature could successfully simulate the type of failure observed in the surface of die steels.

As shown for a typical fatigue sample in Fig. 2, it is possible to duplicate both the checked surface pattern (in one direction) and the oxide-filled crack structure common to service failures in die steels. Thus, the use of this procedure would appear justifiable on the basis of similar failure characteristics.

A cantilever-type bending-fatigue machine was constructed for testing the die steel samples. This machine is illustrated in Fig. 3. The fatigue machine was constructed to permit atmosphere control around the sample and temperature control in the range of 1100 F to 1400 F. A triangular sample was designed with a base of 1 in. and a height of 4 in., as shown in Fig. 4. The reduced section was 1 in. with a minimum width of about ½-in. Sample thickness was 0.120 in.

Room Temperature Bending Strain

The bending strain measured at room temperature by strain gages mounted on dummy samples was used to calibrate the cam. Predetermined cam settings were then used to obtain the desired strain for high temperature tests. Bending load was measured continuously during testing by strain gages on the connecting rod between cam and sample. Applied strain was defined as the total strain applied each half cycle from the maximum deflection in compression to that in tension.

The test end point was selected as the number of cycles at which the bending load was reduced to 50 per cent of its initial value rather than complete sample failure, since this end point was more reproducible. In most cases, the end point preceded sample failure by 100 cycles or less. This end point was selected over complete failure since the samples occasionally failed with an interlocking fracture, which prevented separation even after complete fracture had occurred.

Preliminary studies established that typical corrosion-fatigue failures were observed when the tests were conducted in the temperature range from 1100 F to 1400 F with the applied maximum fiber strain from 0.30 to 0.80 per cent and the strain rate ranging from 5 to 100 cycles/min. One cycle of strain was defined as including one 360 degree cam rotation, such that the sample surface was exposed to the applied strain twice each cycle.

Selected Variables

To facilitate statistical analysis of the data, the individual temperature, strain and strain-rate variables were selected so that each was spaced at equal intervals on a logarithmic temperature, strain or strain-rate

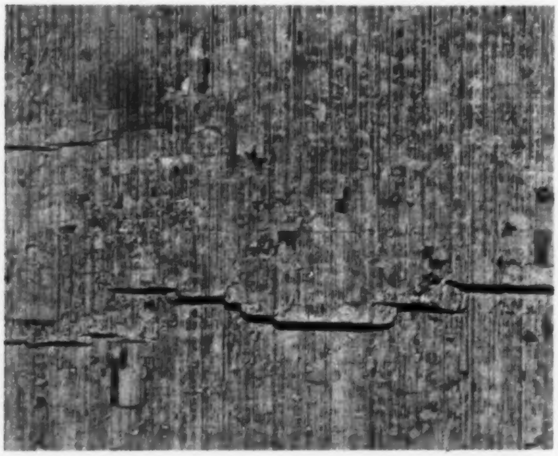
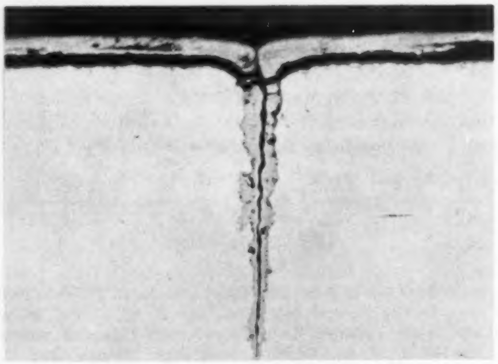


Fig. 2 — (left) Appearance of the surface of corrosion-fatigue sample of H21 steel (10×) and (below) section through a crack after testing in air at 1300 F. Unetched. (250×).



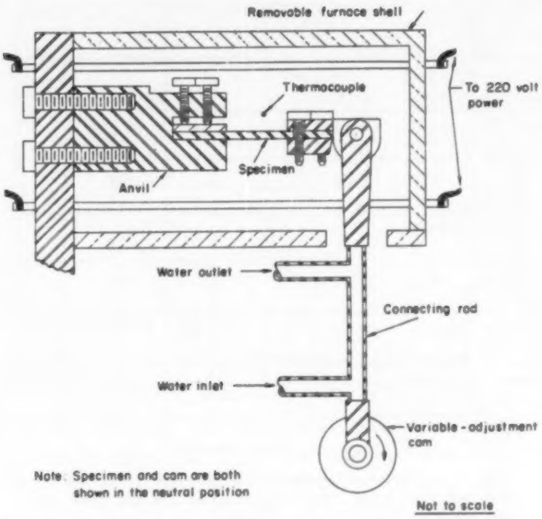


Fig. 3 — Cantilever-bending elevated temperature fatigue testing machine.

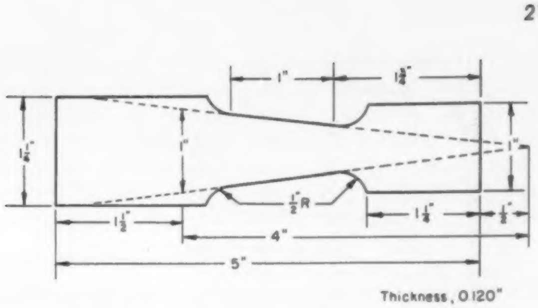


Fig. 4 — Corrosion-fatigue sample.

scale. Four levels were examined in each variable, such that a complete test sequence involved sixty-four separate tests.

As the data were analyzed, it became apparent that much of the variation in sample life resulting from temperature would be eliminated if strain was expressed in terms of plastic strain rather than total applied strain. The plastic strain absorbed each half cycle was determined from stress-strain hysteresis loops representing the behavior of the surface material of the fatigue samples. The stress-strain hysteresis loops were constructed from the tensile data shown in Figs. 5 and 6 and the elastic modulus data shown in Fig. 7.

The procedure followed in obtaining the hysteresis curve may be seen by referring to Fig. 8. This illustration shows the hysteresis curve constructed for a sample of annealed H21 die steel strained 0.8 per cent at 1100 F. A step by step outline of the construction of the curve is:

1) The total strain is divided by two to give the origin, 0.4 per cent strain, point A.
2) The stress-strain curve for annealed H21 at 1100 F (Fig. 5) is plotted (negative stress and strain) to 0 per cent strain, point B.
3) At point B, the elastic modulus at 1100 F (Fig. 7) is used to return to zero stress, point C.
4) At point C, the tensile stress-strain curve at 1100 F is plotted (positive stress and strain) until 0.8 per cent strain is reached, point D.
5) The return portion of the hysteresis curve (DEF) is then constructed using elastic modulus data (D to E) and tensile stress-strain data (E to F).
6) If points F and B were not almost coincident, the portion of the curve BCD was redrawn starting from point F. The new point at D generally coincided with the original point to give a closed loop.

The hysteresis curve in Fig. 8 was then used to determine the plastic strain component by measuring the strain increment between points C and E. The plastic strain for each fatigue test was measured in this manner.

RESULTS

The first objective of this study was to determine the significance of variations in strain, temperature and strain rate on sample life. For this purpose 64 samples of annealed H21 were tested in air under varying conditions selected to permit statistical analysis. The results of these tests are given in Table 2. It is seen that sample life is decreased by increasing strain, increasing temperature or decreasing strain rate. When the results are compared on the basis of plastic strain rather than applied strain, sample life (N) can be empirically related quite simply to plastic strain (S), temperature (T), and strain rate (F) as follows:

$$\log N = 2.721 - 1.927 \log S + 0.223 \log F + 0.012 \log T \quad (1)$$

where N = the number of cycles to end point.
S = the per cent plastic strain observed during the initial half cycle.
F = cycles/min.
T = degrees Kelvin.

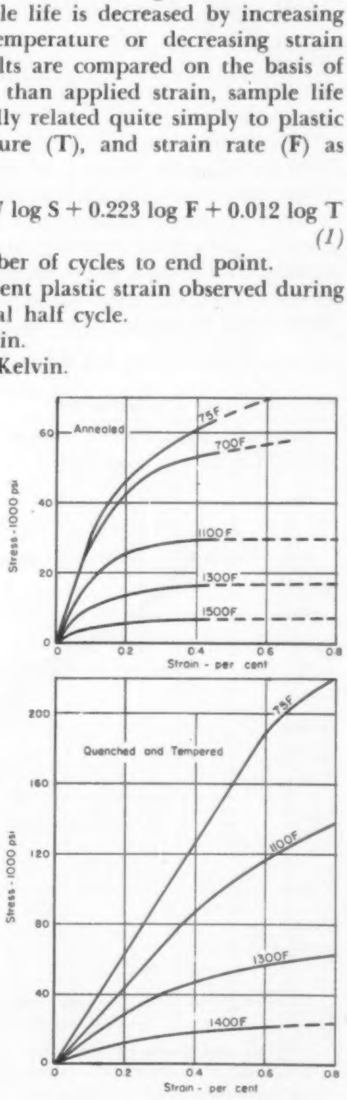


Fig. 5 — Tensile stress-strain curves for H21 die steel.

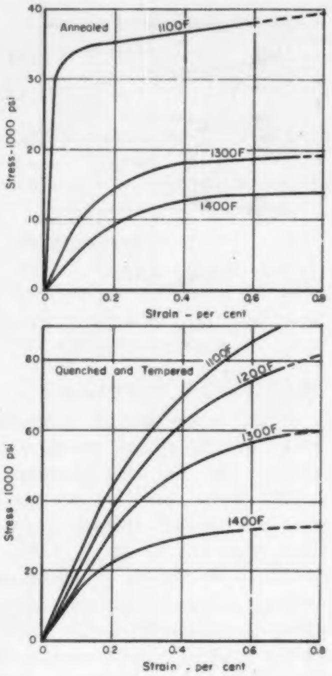


Fig. 6 — Tensile stress-strain curves for H23 die steel.

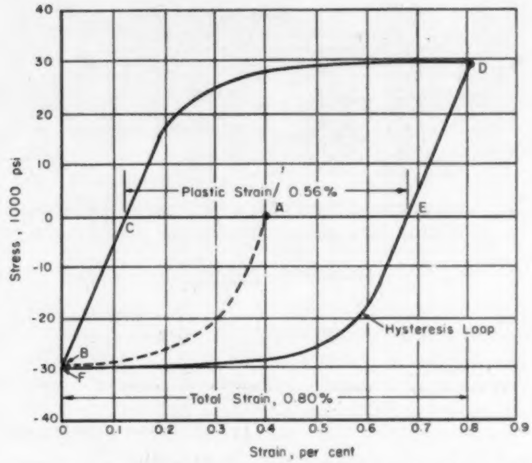


Fig. 8 — Hysteresis loop for fatigue test at 1100 F and 0.8 per cent total strain constructed for annealed H21 die steel.

The standard errors of the constants were 0.024, 0.106, 0.051 and 0.935, respectively. Significance at the 95 per cent probability level requires that a constant in the equation be about twice its standard error or greater. Using this criterion, the temperature effect shown in these data is not statistically significant, so that the equation may be reduced by inserting the main value of temperature in equation (1) to

$$\log N = 2.758 - 1.927 \log S + 0.223 \log F \qquad (2)$$

Second Study Undertaken

Since the temperature variation reported in equation (1) was not significant, it might be expected that the strain-rate effect in equations (1) and (2) is related to some other factor than oxidation. Oxidation should be apparent in both the temperature and strain-rate (reciprocal time) terms of the equation. Therefore, a second study was undertaken in which the above test sequence was partially repeated under a slightly reducing atmosphere (forming gas composed of 10 per cent H_2 and 90 per cent N_2) to eliminate oxidation as a factor in sample failure.

The results of 32 tests run under a reducing atmosphere are given in Table 3. Based on these data, it was possible to write the following equation

$$\log N = 4.949 - 2.046 \log S + 0.121 \log F - 0.652 \log T \qquad (3)$$

with standard errors for the constants of 0.022, 0.100, 0.046 and 0.832. As in the case of tests conducted in air, the temperature term was not significant, but a definite strain-rate effect on sample life existed. The simplified form of equation (3) then becomes

$$\log N = 3.005 - 2.046 \log S + 0.121 \log F \qquad (4)$$

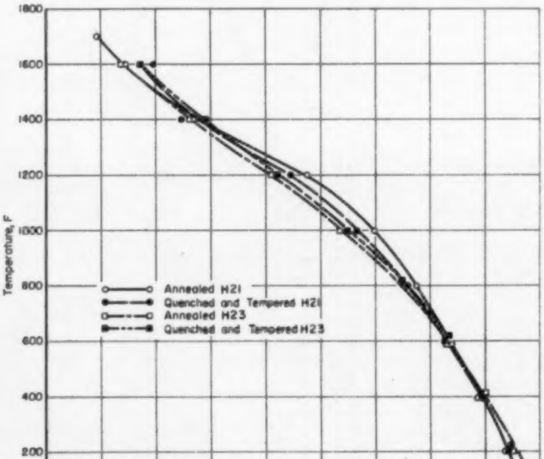


Fig. 7 — Modulus of elasticity of H21 and H23 die steel as a function of temperature, determined by dynamic method.

TABLE 2 — RESULTS OF CORROSION-FATIGUE STUDIES ON ANNEALED H21 DIE STEEL

Temp.,	Strain, %		No. Cycles to End Point at Strain Rate of			
F	Applied	Plastic	5 cpm	14 cpm	37 cpm	100 cpm
1114	0.30	0.100	>70,000	44,330	262,900	85,550
	0.40	0.180	16,650	24,345	22,850	69,450
	0.56	0.330	5,150	7,806	10,150	11,610
	0.80	0.560	2,275	3,725	3,075	3,217
1204	0.30	0.145	37,460	58,400	120,150	190,300
	0.40	0.230	6,450	17,480	26,750	26,770
	0.56	0.380	6,800	5,775	7,285	8,450
	0.80	0.615	2,000	4,700	4,930	3,536
1300	0.30	0.180	28,200	90,550	42,350	35,850
	0.40	0.275	9,367	11,280	14,720	11,710
	0.56	0.425	3,375	4,845	8,660	7,014
	0.80	0.660	4,800	2,610	3,215	4,660
1400	0.30	0.210	8,975	19,780	18,400	35,260
	0.40	0.300	3,700	7,850	9,350	17,650
	0.56	0.455	4,950	3,100	5,220	5,850
	0.80	0.690	5,250	1,900	2,115	2,880

TABLE 3 — RESULTS OF FATIGUE STUDIES ON ANNEALED H21 DIE STEEL[a]

Temp.,	Strain, %		No. Cycles to End Point at Strain Rate of			
F	Applied	Plastic	5 cpm	14 cpm	37 cpm	100 cpm
1114	0.40	0.180	34,180	35,750	30,100	49,260
	0.80	0.560	5,408	5,414	7,165	4,561
1204	0.30	0.145	64,790	83,000	128,830	176,000
	0.56	0.380	9,046	9,062	12,940	15,040
1300	0.40	0.275	15,570	21,550	23,140	26,510
	0.80	0.660	4,426	2,512	5,179	3,260
1400	0.30	0.210	34,450	35,810	30,180	37,340
	0.56	0.455	4,995	4,114	5,529	9,200

(a) All testing carried out in a reducing atmosphere.

This equation is quite similar to that obtained from tests in air, equation (2), indicating that the effect of oxidation on sample life is negligible.

Resistance Variations Effect

Also of interest in this investigation was the effect of variations in the resistance to oxidation, yield strength and resistance to tempering of die steels on behavior under corrosion-fatigue conditions. Sixteen-unit fatigue studies (quarter replicate of original 64 test sequence) were therefore run in air using samples of annealed H23 die steel and of quenched and tempered H21 and H23 die steels. The results of these studies are given in Table 4.

The data obtained from annealed H23 die steel could be represented quite well by an equation similar to those expressed above.

$$\log N = 3.080 - 0.910 \log S + 0.179 \log F \qquad (5)$$

Comparison of this equation with equation (2) indicated a major difference in the effect of strain upon sample life in the two alloys. However, as will be shown in the discussion of tests of quenched and tempered material, there is reason to suspect that this difference is the result of some uncontrolled property change occurring in annealed H23 alloy during test.

Heat Treatment Effect

Heat treatment raises the yield strength (and proportional limit) of the alloys appreciably. Thus, comparing resistance to corrosion fatigue at a constant applied strain shows heat treatment to be decidedly beneficial since the increase in the elastic component of strain results in a corresponding decrease in the plastic component of strain. When the sample life is evaluated at equivalent plastic strain, however, the considerable advantage of heat treatment does not appear. This is shown by the data (open circles) for quenched and tempered H21 die steel in Fig. 9.

It can be seen that, based on equivalent initial plastic strain, quenched and tempered samples are actually less resistant than annealed samples to corrosion-fatigue failure. No doubt this is due to the large degree of tempering occurring during testing. The drop in hardness (Rockwell C scale) occurring in the corrosion-fatigue tests of heat-treated samples are indicated by numbers in parenthesis by each point. Since applied strain is maintained constant, a decrease in hardness would indicate an increase in the plastic strain imposed on the sample during testing.

Thus, the points which show a hardness drop would be expected to be shifted to the right in Fig. 9, if corrected to the average plastic strain throughout the test period. Attempts to relate the amount of shift directly

TABLE 4 — RESULTS OF CORROSION-FATIGUE STUDIES

Temp.,	Strain, %		No. Cycles to End Point at Strain Rate of			
F	Applied	Plastic	5 cpm	14 cpm	37 cpm	100 cpm
			Quenched and Tempered H21 Die Steel			
1114	0.30	0.000	>272,000		>1,440,000	
1114	0.56	0.010	52,000		161,600	
1204	0.40	0.010		101,580		346,200
1204	0.80	0.100		5,700		13,700
1300	0.30	0.035	58,830		166,800	
1300	0.56	0.140	5,675		12,200	
1400	0.40	0.225		10,730		37,850
1400	0.80	0.580		1,650		2,390
			Annealed H23 Die Steel			
1114	0.30	0.015		58,600		203,300
1114	0.56	0.260		8,950		10,850
1204	0.40	0.185	9,600		20,800	
1204	0.80	0.560	2,275		2,675	
1300	0.30	0.150		16,050		21,450
1300	0.56	0.385		4,275		5,325
1400	0.40	0.280	7,525		5,850	
1400	0.80	0.655	2,797		3,042	
			Quenched and Tempered H23 Die Steel			
1114	0.40	0.015		>503,900		>1,126,000
1114	0.80	0.170		6,625		393,100
1204	0.30	0.000	410,600		>2,512,000	
1204	0.56	0.065	64,600		371,800	
1300	0.40	0.055		53,880		249,800
1300	0.80	0.295		4,950		5,850
1400	0.30	0.080	205,500		73,100	
1400	0.56	0.275	4.525		7,775	

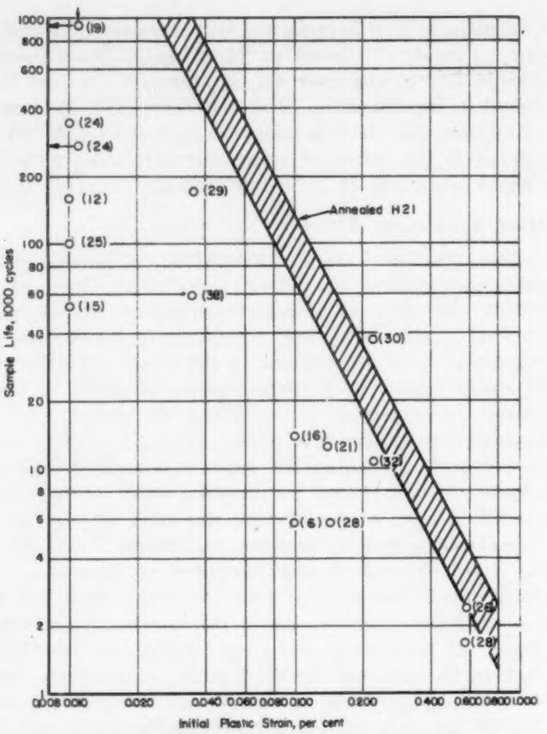


Fig. 9 — Sample life quenched and tempered H21 die steel (loss of Rockwell C hardness during testing given in parentheses). Circles denote points for heat treated H21.

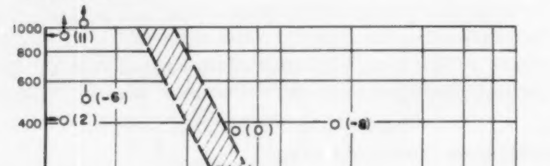


Fig. 10 — Sample life of quenched and tempered H23 die steel (loss of Rockwell C hardness during testing given in parentheses). Circles denote points for heat treated H23.

to tempering were not successful, which indicates that the change in plastic strain value is not a direct function of time, temperature or hardness.

Graph Data

Data from corrosion-fatigue studies on quenched and tempered H23 die steel (open circles) have been plotted in Fig. 10. Two factors of interest are seen in this graph. First, it is obvious that the data from quenched and tempered H23 are much more closely related to those of annealed H21 than of annealed H23, based on equivalent plastic strain. This suggests that the results for annealed H23 were subject to an uncontrolled systematic error. Although limited time did not permit a re-examination of these data, it would appear that some metallurgical change may have been occurring in annealed H23 die steel during testing.

The second observation is that the sample life of quenched and tempered H23 die steel was in much better agreement with that determined for annealed H21 die steel than was that of quenched and tempered H21 die steel. It is probable that this was the result of greater resistance to tempering in H23, as indicated by the slight drop in hardness observed in most samples, such that the average plastic strain occurring during the test period was more nearly equal to the initial (calculated) plastic strain.

Because of uncertainties regarding plastic strain values, no attempt was made to develop for heat treated material equations relating sample life to strain, strain rate, and temperature.

DISCUSSION OF RESULTS

The most striking feature of these studies is that regardless of material strength, tempering resistance or oxidation resistance, or of test temperature, strain rate or atmosphere, the sample life of these die steels was about the same at equivalent cyclic plastic strain. This is illustrated graphically in Fig. 11, where all of the fatigue data from these investigations are plotted as a function of plastic strain. A simplified equation similar to equations (2) and (4) can be written for these data:

$$\log N = 3 - 2 \log S$$

or

$$N = \frac{1000}{(S)^2}$$

Thus, all of these variables affect fatigue life in proportion to their effect on plastic strain.

This equation is quite similar to those observed in low-strain-rate, high-strain fatigue studies on a number of other investigations.* The direct dependence of sample life on plastic strain permits the effects of the other material or testing variables to be easily predicted. Any change which reduces the plastic strain applied to the sample in fatigue loading increases the life of the sample.

If sample life is a function principally of plastic strain, it is apparent that corrosion can be of little

*J. F. Tavernelli and L. F. Coffin, "A Compilation and Interpretation of Cyclic Strain Fatigue Tests on Metals," *A.S.M. Transactions,* vol. 51, p. 438 (1959).

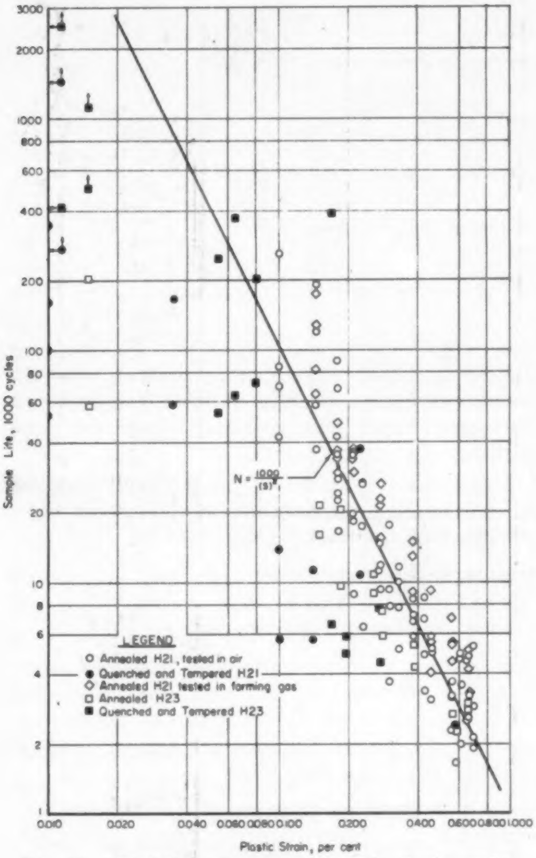


Fig. 11 — Variation of sample life with plastic strain.

Fig. 12 — Appearance of crack in H21 die steel tested in forming gas at 1300 F.

significance. Data on tests on annealed H21 die steel support this conclusion to a marked extent in regard to sample life. However, corrosion does play an important role in controlling the mode of crack formation. Thus, the appearance of the cracks developed in samples tested in air at low temperatures, at high speeds (short times), or in a reducing atmosphere, is quite different from that illustrated in Fig. 2. Only a few surface cracks are formed, and on examination these have an irregular, oxide-free appearance. A typical example of such a crack is shown in Fig. 12. The geometric pattern leading to the designation of the crack pattern as die or heat "checks" is apparently the chief contribution of corrosion to corrosion-fatigue failure in die steels.

CONCLUSIONS

Two hot work die steels (H21 and H23) were examined to determine the relative importance of oxidation and cyclic strain on the corrosion fatigue cracking observed in die steels in service. This study has resulted in the following conclusions:

1. The characteristic geometric crack pattern and oxide-filled cracks of die steels which fail under thermal fluctuations in service can be reproduced by imposing a cyclic strain mechanically at elevated temperature.
2. Through studies of the high-temperature fatigue behavior of two die steels, it was determined that sample life was increased (the onset of cracking was retarded) by reduced testing temperature, increased testing speed, reduced testing strain, increased strength of the material and increased resistance to tempering.
3. If the strain in testing was expressed in terms of plastic strain rather than total strain, temperature and strength of material were found to no longer affect sample life. The effects of these variables on sample life were related to their ability to alter the amount of strain absorbed elastically during fatigue testing.
4. The decrease in sample life resulting from tempering of the material was attributed to changes during testing in the amount of strain absorbed elastically.
5. Conducting the fatigue tests in a slightly reducing atmosphere rather than an oxidizing atmosphere did not affect sample life appreciably. However, the appearance of the cracks formed was altered.
6. Neglecting the small effect of strain rate and taking into account the changes in strength during testing resulting from tempering, sample life (N) was found to vary with plastic strain imposed each half cycle (S) as follows:

$$N = \frac{1000}{(S)^2}$$

7. The appearance of the crack pattern observed in die steels under thermal cycling is the result of oxidation during cyclic strain. However, the life of the die — that is, the onset of cracking — is dependent only upon the magnitude of the plastic component of the thermally induced cyclic strain.

ACKNOWLEDGMENT

This investigation was sponsored by the Die Casting Research Foundation. The continued interest of that group in the research has been greatly appreciated. The authors would especially like to thank O. Laine, W. M. Goldhamer, E. V. Blackman and M. A. Hunter of that organization for their many valuable comments and suggestions during the course of the investigation. Statistical analysis of the data was performed by A. E. Mace, of the Battelle Department of Physics.

JOB EVALUATION—ASSET OR LIABILITY?

by A. G. McNichol

ABSTRACT

The Cooperative Wage Study plan of job evaluation is one which has come into prominence in recent years. The three facets of this plan are 1) job description, 2) job classification and 3) job evaluation. This plan is a labor cost program, the benefits of which usually are indirect and not easily measurable. In combination with other management techniques, job evaluation is a valuable aid. Work measurement is the natural, and necessary, followup of this program.

INTRODUCTION

In 1954 the AFS Industrial Engineering Committee completed the compilation of an outstanding collection of articles dealing with the practical application of Industrial Engineering in foundries. These articles were published by the American Foundrymen's Society under the title TIME AND MOTION STUDY FOR THE FOUNDRY, and are highly recommended reading for all foundry management personnel. Included in this book are two articles on job evaluation; one dealing with the well-known national metal trades plan, and the other presenting the factor comparison method of job evaluation.

It is hoped that this paper will supplement these articles by presenting an outline of the Cooperative Wage Study plan which has come into prominence in recent years. At the same time, I hope that the opinions expressed and the conclusions drawn may be of some benefit to those who do not have job evaluation in their companies and are contemplating the installation of such a program.

"Cooperative Wage Study" (C.W.S.) refers to the job evaluation program developed jointly by management and union under directive of the National War Labor Board during the years 1943 to 1945. The joint committee was composed of representatives from 12 major steel companies and a seven man team from the United Steelworkers of America (C.I.O.). Following the negotiation of the manual and related wage agreements, the program was adopted in some 86 companies, and eventually covered some 25,000 jobs in the basic steel industry.

Since that time, C.W.S. programs have been promoted by the United Steelworkers in the other industries for whom they are bargaining agents. The result is that this job evaluation plan in recent years has become fairly common in a variety of industries including light and heavy plate fabrication, structurals, foundries, forgings, machine tool and equipment manufacturers, mines and electrical equipment manufacturers.

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Any company considering the advisability of using job evaluation must certainly want to know the answers to such fundamental questions as:

What is job evaluation?
What will it cost?
What benefits can be expected?

The answers to these and other questions will be drawn by reference to, and with illustrations from, the application of the C.W.S. program. In most cases, however, the points discussed are equally applicable to other job evaluation plans.

WHAT IS JOB EVALUATION?

There is some confusion in the use of the terms Job Evaluation, Job Description and Job Classification. Additional confusion is introduced by the use of such other related terms as Job Analysis, Job Specification, Job Ranking and Job Pricing.

In a straightforward point evaluation plan such as C.W.S., three terms only are necessary. These are:

1) *Job Description.* The factual statement of the important functions which comprise the job content.
2) *Job Classification.* Procedures by which the functions are analyzed and measured in terms of relative worth according to the factors used in the plan.
3) *Job Evaluation.* The term used to embrace the entire program, and includes both the job description and job classification processes.

Perhaps the best way to explain job evaluation is by consideration of the basic economic needs which fostered its development.

In modern society, man usually purchases goods offered on the market at a given price. To a degree there are some traces remaining of the barter system, but, in general, most transactions result in the exchange of a required number of dollars for an article of known size, shape, material, quality, and so forth.

When the commodity to be sold is labor, however, the establishment of a fixed price for a given service is extremely difficult. It may be argued that the laws of supply and demand will produce an answer to this question, and they do. Unfortunately, the answer arrived at in this manner usually determines only one

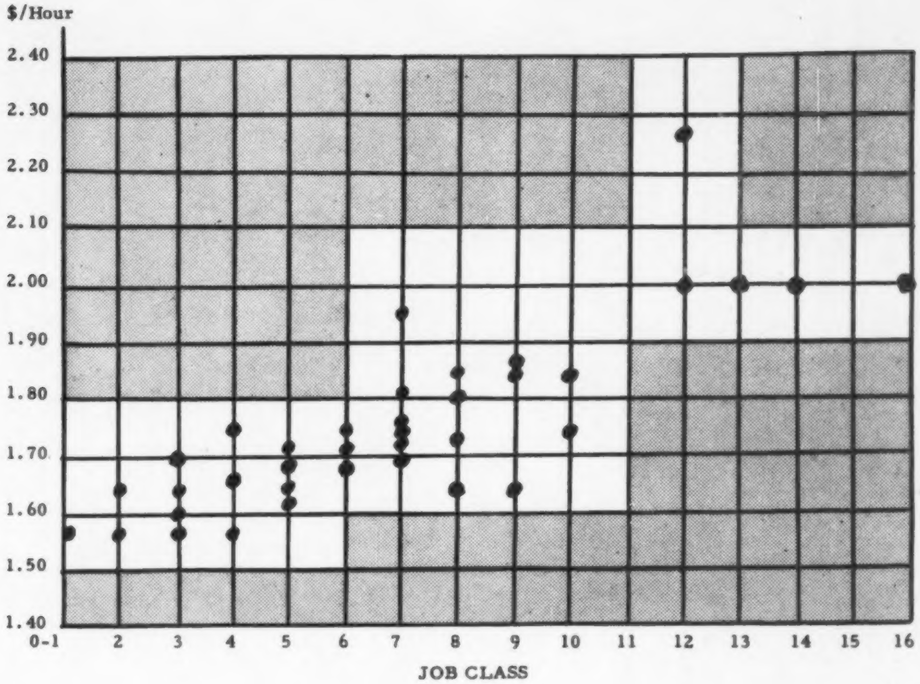

Fig. 1 — Scatter chart illustrating wages paid prior to job evaluation.

side of the equation—the dollar value to be paid. The services to be rendered in return for the agreed upon wage are rarely defined in such a way that either party knows exactly what is expected of the worker.

Job evaluation was developed in industry as a means of defining and measuring the work functions to be performed. It must be recognized, however, that the measurement mentioned here is the measurement of the job functions, responsibilities, conditions, and so forth. It is not a measurement of the quantity of work required. The process may be considered as one which determines the quality requirements of each job, but it must be emphasized that job evaluation does not measure the quantitative requirements. This most important supplement to job evaluation is determined through work measurement procedures.

Job evaluation, then, is the procedure by which management (or management and union together) define the functions of each job and determine the relative worth of the job when it is performed by a competent employee working at a normal pace.

C.W.S. PROGRAM OUTLINE

Perhaps a brief examination of the C.W.S. program will explain better than a generalized text.

Figure 1 shows a fairly typical scatter chart of wage rates in a plant prior to job evaluation. Two points are worthy of note:

1) There is little or no pattern to be observed.
2) There are numerous instances where high-skill jobs on the right side of the chart are paid less than low-skill jobs on the left.

Figure 2 shows the results after job evaluation. The progression of wage rates from the lowest job class to the highest, fall in a straight line with an equal increment, or step, between each job class.

Table 1 illustrates a job description. In essence this is the identification of the job in increasing detail as you read from the top of the page to the bottom. The title is amplified by the notation of department and subdivision. This is followed by the "Primary Function" which is a one sentence condensation of the major responsibilities. Further job identification is provided under the headings of "Tools and Equipment," "Materials," "Source of Supervision" and "Direction Exercised." The description is completed by outlining in fairly general statements and working procedure followed in performing the job functions. The statement on the bottom of each job description should also be noted (This a printed on the form used).

Job Classification

Having completed the description of the job, the next step is the job classification. In this part of the program the job responsibilities, conditions, and so forth, are measured against the *Job Classification Manual.*

The manual is composed of 12 factors, each of which is subdivided into a number of levels. Each level has a point value, and by determining, from the definitions provided, which level is most applicable for a given job, the factor value is immediately obtained. The sum of the 12 factor values determines the job class.

Table 2 shows the 12 factors and the maximum value for each. To a certain extent these maximum values are misleading since the operative areas of the factors in most installations would indicate a much different effective factor weighting. Some consideration

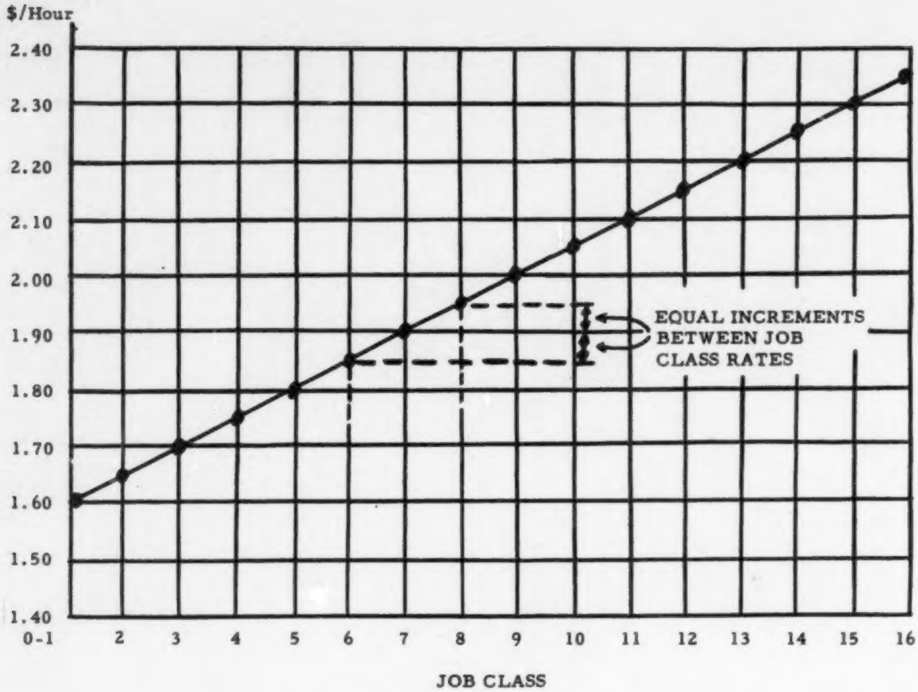

Fig. 2 — Wage curve illustrating wages paid after job evaluation.

has been given to the advisability of adjusting some of the factor values for application of the C.W.S. manual in the mining and structural fabricating industries has been reported to the author. Apparently such attempts were dropped and the author is unaware of any changes having been made to the original factor weightings developed in the basic steel industry.

Table 3 shows the definitions and values for the levels in Factor 3, "Mental Skill." The other factors in the manual are presented in the same manner. A base, or zero value, is provided for the minimum requirements of level *A* and progressively higher values, arranged in irregular steps, are given for higher degrees in the factor.

Job Description

The job classification form (Table 4) is printed on the reverse side of the job description. On this form, the selected factor level definitions and the corresponding numerical values are recorded. The sum of the factor values (rounded to the nearest whole number) is the job class.

WHAT IT WILL ACCOMPLISH

This outline of the C.W.S. program has been greatly condensed and simplified in order to cover only the essential points without too much of the detail which would be confusing. The manual and wage agreement include instructions for the company and union committees. Specific procedures are outlined for the treatment of tradesmen, apprentices, learners, leaders, inspectors, out-of-line differentials, and so forth.

Properly applied, job evaluation will result in equitable wage rates for all jobs in the plant. With care, they will be reasonably equitable within the community and the industry. It should be noted that the reference here, and throughout this paper, is to wage rates for jobs, not wage rates for individuals. The selection, placement and rating of individual employees in their assigned tasks, although a related problem, must be considered separately.

A sound job evaluation program not only measures the relative worth of each job at the time of installation, but also provides the mechanisms for maintaining the proper relationships in the future. New or revised jobs created through changes of equipment, processes and procedures must, of course, be integrated into the program.

A third benefit which is to expected is a structure of base rates which provides a sound basis on which to build work measurement or wage incentive programs. Comments on this point will be presented a little later.

A fourth accomplishment will be elimination of the perpetual problem of adjusting inequitable wage rates during the annual labor contract negotiations or even during the life of the contract. A major provision of the C.W.S. agreement is that, after the program is completed, there shall be no claims of wage inequities submitted or processed.

The job evaluation program will provide basic information for management use in costing, estimating, scheduling, and so forth. This information is invaluable for use in work measurement programs and the analysis and improvement of organization structures. Job descriptions are most useful for personnel relations activities such as hiring, transferring, training and promoting.

WHAT IT WILL NOT ACCOMPLISH

Job evaluation will not solve all the labor problems for the plant manager. While it will reduce or eliminate grievances over wage rates, it will have virtually no effect, nor should it have, on the multiplicity of other employee grievances.

Secondly, job evaluation will not increase the productivity of the labor force. Since only the qualitative job requirements have been measured, the new rate structure will have no direct effect on work output per man.

Job evaluation will not improve the quality of workmanship or skill of the workers. It may be argued that the desire to move into a higher job classification will inspire workers to self-improvement and the attainment of necessary qualifications for advancement. A more realistic result, unfortunately, is the elimination

TABLE 1 — SPECIMEN EXAMPLE OF JOB DESCRIPTION

Department .....Maintenance	Std. Code ....
Subdivision ....Machine Shop	Std. Title ....Machinist
Plant	Plant Title ....Machinist "A"
Date	Plant Code ....

Primary Function:

To lay out work, set up and operate machine tools and perform any dismantling, fitting or assembly work required for plant maintenance or construction.

Tools and Equipment

All usual types of machine and hand tools common to the trade.

Materials

Used: Ferrous, non-ferrous and nonmetallic materials; cutting oils, grinding compounds and other processing materials.

Produced: Machined parts or assemblies.

Source of Supervision

Foreman or immediate supervisor.

Direction Exercised

Works alone or directs helpers and other workmen as required.

Working Procedures

Receives instructions, prints and work orders.

Interprets drawings and sketches; plans and determines working procedure.

Performs any layout work and makes sketches of parts as required.

Calculates and determines dimensions, tapers, indices and other data, using shop formulas and handbooks as necessary.

Selects and grinds tools for the job in accordance with hardness, machinability and other properties of parts to be machined.

Procures or makes jigs, fixtures or machine attachments required for the job.

Sets up and operates machine tools, adjusting stops, feeds and speeds for efficient machining.

Machines parts to precision tolerances and specified finishes.

Uses precision measuring instruments.

Dismantles machinery and equipment.

Assembles, fits, aligns and adjusts machinery and equipment to close tolerances.

Works in shop or field as required.

The above statement reflects the general details considered necessary to describe the principal functions of the job identified, and shall not be construed as a detailed description of all the work requirements that may be inherent in the job.

TABLE 2 — C.W.S. FACTORS AND WEIGHTINGS OF MAXIMUM VALUES

Item	Maximum Value	
1. Pre-Employment Training	1.0	2%
2. Employment Training and Experience	4.0	9%
3. Mental Skill	3.5	8%
4. Manual Skill	2.0	5%
5. Responsibility for Materials	10.0	23%
6. Responsibility for Tools and Equipment	4.0	9%
7. Responsibility for Operation	6.5	15%
8. Responsibility for Safety of Others	2.0	5%
9. Mental Effort	2.5	6%
10. Physical Effort	2.5	6%
11. Surroundings	3.0	7%
12. Hazards	2.0	5%
	43.0	100%

TABLE 3 — C.W.S. FACTOR LEVEL DEFINITIONS AND VALUES

FACTOR 3 MENTAL SKILL

Consider the mental ability, job knowledge, judgment and ingenuity required to visualize, reason through, and plan the details of a job without recourse to supervision.

Code	Job Requires Ability To	Benchmark Jobs	Numerical Classification
A	Perform simple, repetitive routine tasks. Do simple sorting. Make changes in routine only when closely directed.	Laborer Stocker O. H. Wharfman—C. P. Scrapman—Bil. Shr.	Base
B	Make minor changes in routine or sequence on repetitive jobs involving selection, positioning and recognition of obvious defects or adjustments where tolerances are liberal.	Charger Bar Mill Wire Bundler Pipe Stenciler	1.0
C	Perform semi-routine job involving some variety of detail and requiring judgment. Sort material according to size, weight or appearance.	Chipper—Cond. Bottom Maker S. P. Stitcher Oper. Assorter—Tin Plate Tractor Operator—Ram Craneman—H. S.	1.6
D	Reason through problems involving setup and operation of moderately complex equipment. Use considerable judgment in operating equipment. Exercise considerable judgment in selecting and using materials, tools and equipment in construction, erection or maintenace work.	Slitter Operator Finisher—H. S. Charging Mach. Oper. O. H. Ore Bridge Oper. Carpenter Bricklayer Millwright—B. M.	2.2
E	Plan and direct the operation of a large complex production unit. Reason through and plan operating problems. Plan work detail from complex blue prints.	Tandem Mill Roller 1st Helper—O. H. Machinist Boilermaker	2.8
F	Analyze and plan complex nonrepetitive tasks to be performed by skilled workmen.	Layout Men (Development Work)	3.5

TABLE 4 — SPECIMEN EXAMPLE OF JOB CLASSIFICATION

Plant Title: Machinist "A" Std. Title: Machinist

Factor / Reason For Classification	Code	Classification
1. *Pre-Employment Training. This job requires the mentality to learn to:* Interpret detailed assembly & complex part drawings. Apply practical knowledge to work involving considerable variation in operation, construction and repairs.	C	1.0
2. *Employment Training and Experience. This job requires experience on this and related work of:* From 37 to 48 months of continuous progress to become proficient.	H	3.2
3. *Mental Skill* Select materials and plan work. Interpret complex part drawings. Make shop and field sketches.	E	2.8
4. *Manual Skill* Use various machine tools and hand tools to perform tasks involving close tolerances.	D	1.5
5. *Responsibility for Material* Close attention in laying out and machining work to close tolerance. Estimated Cost $500. or Under. Failure to hold tolerance may cause extra machining, scrapping of materials, machinery or equipment.	E	3.2
6. *Responsibility for Tools and Equipment* Moderate attention and care required to avoid damage to machine tools. Damage tradesman's tools by dropping, carelessness, improper use.	C Med.	0.7
7. *Responsibility for Operations* Individual processing operation involving use of complex machine tools.	C	1.0
8. *Responsibility for Safety of Others* Ordinary care and attention required to prevent injury to others. Operate machine tools where others are occasionally exposed. Occasional crane hooking.	B	0.4
9. *Mental Effort* Close mental or visual application required to plan and lay out work and interpret drawings and sketches. Grind tools, gauge work and adjust equipment for proper metal removal.	D	1.5
10. *Physical Effort* Light physical exertion required to manipulate light controls, grind tools, use light hand tools, clean up, etc.	B	0.3
11. *Surroundings* Machine shop conditions.	A	Base
12. *Hazard* Accident hazard moderate. Exposed to hazards of revolving machinery and crane hooking such as mashed fingers or sever cuts.	B	0.4
Job Class 14	Total	16.0

Reviewed and Approved by:

Chairman ,Union Job Classification Committee

Chairman, Management Job Classification Committee

Described by Date:

Classified by

Approved by

of individual initiative through the establishment of equal rates for all employees on a given job, regardless of individual differences of knowledge, ability and effort. This disadvantage, of course, is as much a result of the seniority provisions in the labor contract as it is in a result of job evaluation.

Except in a company that has no incentive plans, job evaluation will not solve all the wage rate problems. Where there are existing incentives, the establishment of job evaluation invariably will create new problems in areas where there had been none previously. Existing piece rates probably will require revision, many incentives may be submerged by higher base rates to the point of being ineffectual, and allowed-hour plans on higher base rates may disclose unwanted discrepancies in total earnings comparisons with higher skilled, but nonincentive occupations.

PITFALLS OF MANY INSTALLATIONS

The fact that job evaluation appears to be straightforward, easily understood procedure creates the first possible trap for the uninitiated. There is nothing mysterious about job evaluation. There are many facets to be considered, however, and even the smallest company would be well advised to seek professional guidance in the selection or development of a plan, the negotiation of wage agreements and training of personnel.

While outside help is desirable during the installation phase, it must be remembered that this is a continuing program. The primary purpose of consultants in this case should be to train plant personnel who will be capable of the necessary administration and future maintenance of the program. At any instant, job evaluation is only as good as it is currently accurate, both in the description of job content and in the measurement of the value of the job. Since no plant long remains static, it can be seen that maintenance of the program on a current basis is a prerequisite to success.

Selection of personnel to conduct the program is important. In the first place, no one man should attempt the job alone. Since job evaluation depends on human judgment, the principle of multiple judgment through the use of a committee is highly desirable. In many installations this principle is extended even further by the creation of two committees, one representing the company and one representing the union. A real advantage to this approach is the sense of participation by the workers and the acceptance of the results as being fair and equitable.

Committee Selection

The selection of four, or six people to work as two committees is often difficult, particularly in a small plant. The author believes it is important that neither the plant manager nor the local union president serve on the committees. Even if they both have the required characteristic of objectivity, they should be reserved for second-line negotiation of the agreement within which the committees function. As in any other form of negotiation neither side gets everything it wants. The union committee can expect to be unpopular with some segments of the plant working force when the program is completed. In one case at least,

the local union president, who had served as chairman of the union job evaluation committee, found himself voted out of office in the next election.

Job Rating

One pitfall which is common to every type of plan, although more prevalent in some than in others, is the continual temptation to think (and rate) jobs in terms of the individual employee on the job. Besides the characteristic of objectivity, the evaluators require the ability to consider each job impersonally without thought of the employee concerned. This is most difficult in small plants, but nonetheless essential to the success of the program.

A pitfall which one would imagine every company would consider is the cost of the program. This can be estimated fairly accurately with little difficulty by a competent adviser. Such an estimate should be prepared before management and union meet to negotiate such monetary items as base rate and increment between job classes. One practical approach to this problem is for the parties to negotiate an agreed-upon amount of money (such as $0.10 per hr) to be used for job evaluation. This provides management with a known cost commitment, and union with a fixed average increase for the employees. It also facilitates the negotiation of job classifications, since neither side has anything to gain in total dollars by unwarranted bargaining over individual jobs.

It should not be necessary to advise a business man to read the fine print in a document. However, in the case of the steelworkers' C.W.S. program this is most important. The C.W.S. manual of 12 factors is a straightforward point evaluation plan. The attached appendices which outline the conventions to be applied for leaders, spell hands, tradesmen, apprentices, learners, inspectors, and so forth, are also part of the wage agreement, or manual as it has come to be known. Since each one of these conventions costs money, the importance of fully understanding all the terms of the agreement is readily apparent.

Purpose of Program

In any job evaluation program it must be expected that traditional wage relationships will be altered to some extent. This, after all, is the purpose of job evaluation unless the original rate structure was properly arranged, in which case there would be no need for an evaluation program. The point which should be appreciated by foundries contemplating a job evaluation program using the C.W.S. manual, is that this manual was developed by and for the basic steel industry. Consequently, the traditional wage relationships on which the factors were based are not identical with the traditional wage relationships of the foundry industry.

In most cases, the differences probably are minor, but there may be some comparisons which will seem incomprehensible to the foundryman. For example, one plant manager was horrified to discover that both his lift truck operator (who delivers molten iron) and his production molders (on heavy repetitive work) were classified in job class 9. Traditionally, the lift truck position was easy to fill and carried a rate some $0.07 above base labor, which is the approximate equivalent of job class 3.

In this particular case, the comparison of total earnings and the incentive opportunities of the molders' job established a satisfactory spread above the lift truck earnings. The point remains, however, a job evaluation program from one industry may establish wage relationships which differ materially from the historical relationships (and therefore would be undesirable) in another industry.

WORK MEASUREMENT NEEDED

The final pitfall which is included here is not inherent in the job evaluation program itself. As noted earlier job evaluation determines the proper wage to be paid to a competent employee working at a normal pace. This, in effect, establishes one half of the phrase which has often been applied to the C.W.S. program: "A fair day's pay for a fair day's work." The establishment of the other half of the phrase, the "fair day's work" must be developed by management, using some form of work measurement such as time study, predetermined times or work sampling. To the author it seems the height of inconsistency for a company to install job evaluation and not follow it up with a work measurement program to ensure that proper value is received for its payroll dollars.

CONCLUSION

By itself, job evaluation should not be considered a cost reduction tool in the sense that it will produce direct savings similar to wage incentive and methods programs. On the contrary, job evaluation must be recognized as a labor cost item, the benefits of which usually are indirect and not easily measurable. These benefits often are deferred for a period of months or years, and usually manifest themselves in the form of increased morale and harmony in the labor force.

In combination with other management techniques, job evaluation is an invaluable aid. The simple process of properly identifying each job with a title and description of the job functions invariably leads to analysis of work assignments and improvements in the plant organization. A natural, and necessary, followup to job evaluation is work measurement, the uses and benefits of which are manifold. Without attempting to include any discussion of work measurement in this paper, it should be noted that in one of its major fields, wage incentives, there is every danger that a well-designed incentive system can fail miserably unless it is applied to a sound base rate structure developed by job evaluation techniques.

This, then, is the conclusion to which the author has come in his own thinking on this subject. Job evaluation is an expense item of limited measurable value unless it is treated as the essential first step in a comprehensive industrial engineering program which uses job evaluation as one of the bases for establishing the multitude of true cost reduction activities. To each individual must be left the question which began this discussion: "Job evaluation, asset or liability?" This must be answered according to the particular company situation and the policy which its management adopts.

MICROSTRUCTURAL CHANGES UPON TEMPERING NICKEL CHROMIUM WHITE IRON AT 400F

by J. R. Mihalisin and R. D. Schelleng

ABSTRACT

A tempering treatment at 400 F is usually applied to martensitic irons and steels used for abrasion resistant castings. It is shown that such a tempering treatment alters the appearance of the martensite plates under polarized light. Electron micrographs show a precipitate within the tempered martensite plates and an electron diffraction analysis of the precipitate discloses that it is epsilon carbide.

WHITE IRON STUDIED

Martensitic white cast irons are used to advantage in many locations where resistance to abrasive wear is important. Typical uses include grinding mill liners and balls, slurry pumps, roll heads, auger conveyors, etc. The martensitic matrices of such irons are produced in the as-cast state through alloying conditions. A great variety of compositions are used depending upon service conditions.

The alloy studied in this work has the following nominal composition in per cent by weight:

C	Si	Mn	Ni	Cr
3.3	0.5	0.5	4.5	2.0

The hardness of this material normally is about 600 Bhn. The microstructure consists of large amounts of massive carbide surrounding martensitic dendrites. Usually a significant amount of retained austenite is present in the as-cast condition. Rote[1] has reported isothermal and martensite transformation data for such an iron. The *Ms* temperature was found to be about 200 F, and the *Mf* temperature was reported to be in the vicinity of minus 200 F.

Early in the development of irons of this type it was learned that a significant improvement in the toughness of the material results from a tempering treatment at 400 F for about 4 hr. No noticeable sacrifice in wear resistance results from this temper, and the utilization of such a heat treatment has become standard practice for these irons. Abrasion resistant, martensitic, high carbon steels also benefit from such a tempering treatment.[2]

MICROSTRUCTURAL CHANGES STUDY

Since tempering of martensitic white iron castings at 400 F had been found to be of considerable benefit to service ability, a brief study was made of the microstructural changes produced by the heat treatment.

Microstructural examinations of tempered and untempered iron specimens were made. The well-known difference in etching response between the as-cast and tempered material was observed, but no marked change in the microstructures could be seen at the magnifications possible by light microscopy. However, when the etched microstructures were viewed under polarized light with an analyzer perpendicular to the polarizer, a marked difference in appearance was observed.

The martensite plates in the tempered material appeared light while the martensite in the as-cast sample appeared dark. Photomicrographs illustrating these observations are shown in Fig. 1. When the sample is rotated with respect to the plane of polarization of the light, the martensite plates in the tempered iron appear alternately light and dark four times in one revolution. The as-cast martensite plates show only a slight change in brightness, and remain dark in comparison with the tempered martensite.

ELECTRON MICROSCOPY

Electron micrographs of the material are shown in Figs. 2 and 3 in the as-cast and tempered conditions, respectively. The martensite plates appear homogeneous as-cast, but tempering at 400 F for 5 hr causes a lamellar precipitation of a second phase within the martensite plates. Small amounts of bainite formed from the retained austenite can also be seen.

The occurrence of this lamellar precipitate in the martensite is responsible for the lack of extinction of the polarized light with crossed polarizers. This response of an etched lamellar phase to polarized light

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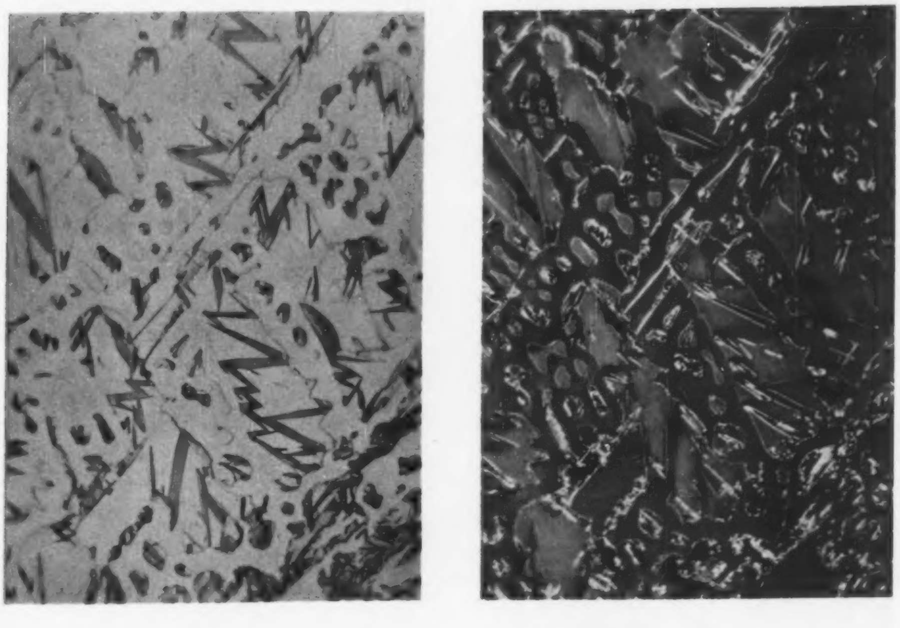
As-cast

Tempered at 400 F for 5 hr



Normal light

Polarized light

Fig. 1 — Tempering at 400 F effect on the appearance of martensite in nickel, chromium white iron under polarized light. As-cast martensite appears dark; tempered martensite appears light.

Fig. 2 — Microstructure of as-cast martensitic nickel, chromium white iron negative parlodion replica shadowed with germanium at 20 degrees from the normal to the plane of the replica. 5500 ×. Nital etch.

Fig. 3 — Microstructure of martensitic nickel, chromium white iron tempered at 400 F for 5 hr. Negative parlodian replica shadowed with germanium at 20 degrees from the normal to the plane of the replica. Nital etch. 5500 ×.

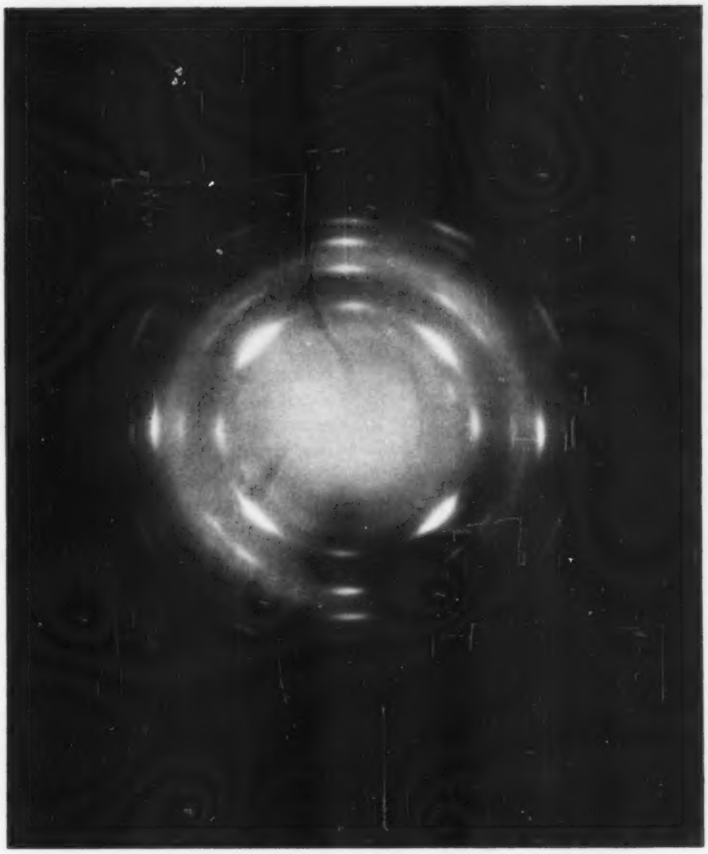


Fig. 4 — Electron diffraction pattern from extraction replica of martensitic, nickel, chromium white iron tempered at 400 F for 5 hr.

d (obs.)	ε-Carbide (5)
2.39A	2.38A
—	2.16
2.08	2.08
1.60	1.60
1.37	1.37
1.23	1.24
1.14	1.16

has been previously observed.[3] It has been found that extinction of the polarized light will occur only when the lamellar precipitate is parallel to the plane of polarization of either the polarizer or analyzer.

Particles for identification of the lamellar phase were removed from the martensite of the sample tempered at 400 F by an extraction replica technique.[4] An electron diffraction pattern obtained from the extracted phase is shown in Fig. 4. The corresponding *d* spacings for ε-carbide is excellent. It is interesting to note that the observed spacings here compare well with those observed by Boswell on carbides in tempered low carbon iron.[6] This indicates that the tempering reactions in the white cast iron examined here are similar in behavior to those in irons and steels.

The increase in toughness of the material after tempering at 400 F apparently is due to this precipitation of ε-carbide which allows the highly strained tetragonal lattice of martensite to relax forming cubic martensite.

ACKNOWLEDGMENT

The authors are grateful to The International Nickel Company, Inc., for permission to publish the results of this study.

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SOLIDIFICATION OF ALUMINUM CASTING ALLOYS

by R. E. Spear and G. R. Gardner

ABSTRACT

The manner in which several aluminum alloys solidify has been investigated. The formation of matrix material and constituents was observed by metallographic and microradiographic techniques at various stages of solidification.

The procedure consisted of cooling small molten specimens at relatively slow rates to various temperatures within the solidification zone, then quenching in water. That portion of the alloy which had solidified during the initial slow cooling rate was distinguished by its relatively coarse structure from the more rapidly solidified material. Thus, by examining a series of specimens the sequence and manner in which the complete structure was formed could be established.

The results indicated that the matrix solidified by forming primary dendrites and by deposition around constituents. The latter phenomenon appeared to be of a magnitude which might influence the feeding and hot cracking characteristics of some of the alloys. The dendrite shape varied with alloy composition and solidification rate. Solid solution alloys contained more equiaxed and deeply fissured dendrites than alloys having appreciable amounts of constituent material. The dendrite structure became more refined and complex with increasing solidification rates.

The grain size for all alloys investigated was established in the early stages of solidification. The compact dendrite form of the solid solution alloys apparently contributed to slightly smaller grain sizes for these alloys.

For the same solidification rate, constituents which formed near the liquidus tended to be larger than constituents which formed near the solidus.

INTRODUCTION

Within the last 20 years, a considerable amount of work has been published on the solidification of metals.* However, there remain a number of unresolved questions concerning solidification. One reason for this is the opaque nature of metals which prevents visual observation of solidification except at free surfaces.

The present work has attempted to describe the manner in which several aluminum alloys solidify by a technique that provides a visual indication of the process in a secondary manner. The technique consisted of slowly cooling small specimens to temperatures within the solidification zone and then quenching them in water. The material which solidified during the slow cooling period was detected in the solidified specimen by its relative coarseness compared to the material which solidified during the quench.

A test procedure quite similar to this was used by M. O. Smith[1] for a metallographic examination of some aluminum alloys. The object of the present work differs from that of reference (1) in that the primary concern was the solidification process rather than the identification of constituents.

PROCEDURE

The specimens used in this work were truncated cones 2-in. high, tapered from ¾-in. diameter at the bottom to 1½-in. diameter at the top. The original stock was cast to this size in a metal mold from degassed, induction-melted heats. Each specimen then was placed in a thin-wall, cast iron crucible of similar dimensions and remelted in a resistance furnace. After melting, a thermocouple was inserted along the center line of the sample so that its bead was approximately ¾-in. from the specimen bottom. The subsequent thermal history of the specimen was recorded through this thermocouple on a single-point, continuous recorder.

Each specimen was heated to 1400 F, cooled to a selected temperature at a controlled rate, then quenched immediately to room temperature in tap water. The temperatures from which the specimens were quenched were selected from a typical cooling curve of each alloy examined. Approximately ten temperatures were investigated for each alloy. Of these conditions, the more interesting and revealing have been incorporated in this paper.

Two cooling methods were followed. One schedule consisted of furnace cooling followed by a room temperature water quench. The second schedule consisted of air cooling plus a water quench. The cooling rate in the furnace, as measured just above the liquidus, was approximately 0.03 F/sec. The rate of cooling in air was approximately 3.0 F/sec.

The cross-section of each casting was examined microradiographically and metallographically. The microradiographs were made with copper radiation using 0.010-in. thick specimens. The cross-sections were taken immediately below the thermocouple bead so the thermal history might be known accurately.

*References are at end of the text.

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The chemical compositions of the alloys investigated are listed in Table 1.

RESULTS AND DISCUSSION

The sequence and manner in which the alloys solidified is illustrated in Figs. 1 – 4. Accompanying each figure is a cooling curve typical of the 0.03 F/sec cooling rate. The temperatures from which specimens were quenched into water are indicated on the curves. The microstructures of the resulting specimens are shown along with curves pictured, numbered to correspond with the point on the cooling curve from which they were quenched.

In the following discussion, the metallurgical structure has been divided into matrix and constituents. The term constituent in this regard includes all metallic material excepting the aluminum solid solution.

Matrix

A large amount of the matrix material solidified in the normal dendritic fashion. The first micrograph in all of the figures illustrates the early formation of this dendritic material.

It is to be expected that the dendrites will vary with changes in the solidification rate and the alloy

TABLE 1 — CHEMICAL COMPOSITION

Element	Alloy No. and Composition, %			
	220	142	319	355
Cu	0.01	4.35	3.49	1.14
Fe	0.13	0.37	0.72	0.21
Si	0.10	0.38	6.10	4.90
Mn	0.02	0.03	0.52	–
Mg	10.4	1.32	0.23	0.50
Zn	<0.02	0.04	0.40	0.02
Ni	–	2.03	0.14	–
Ti	0.01	0.12	0.11	0.13
Na	–	–	–	0.001
Ca	0.001	–	–	0.001

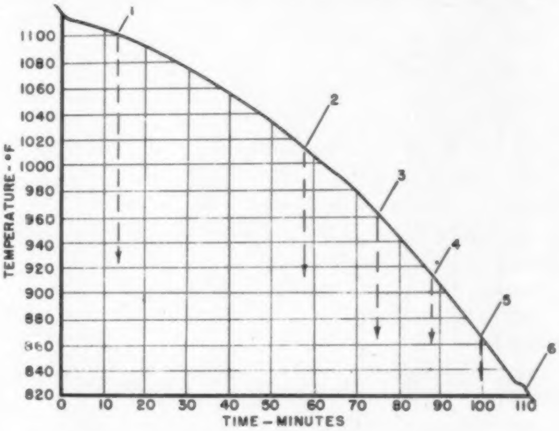
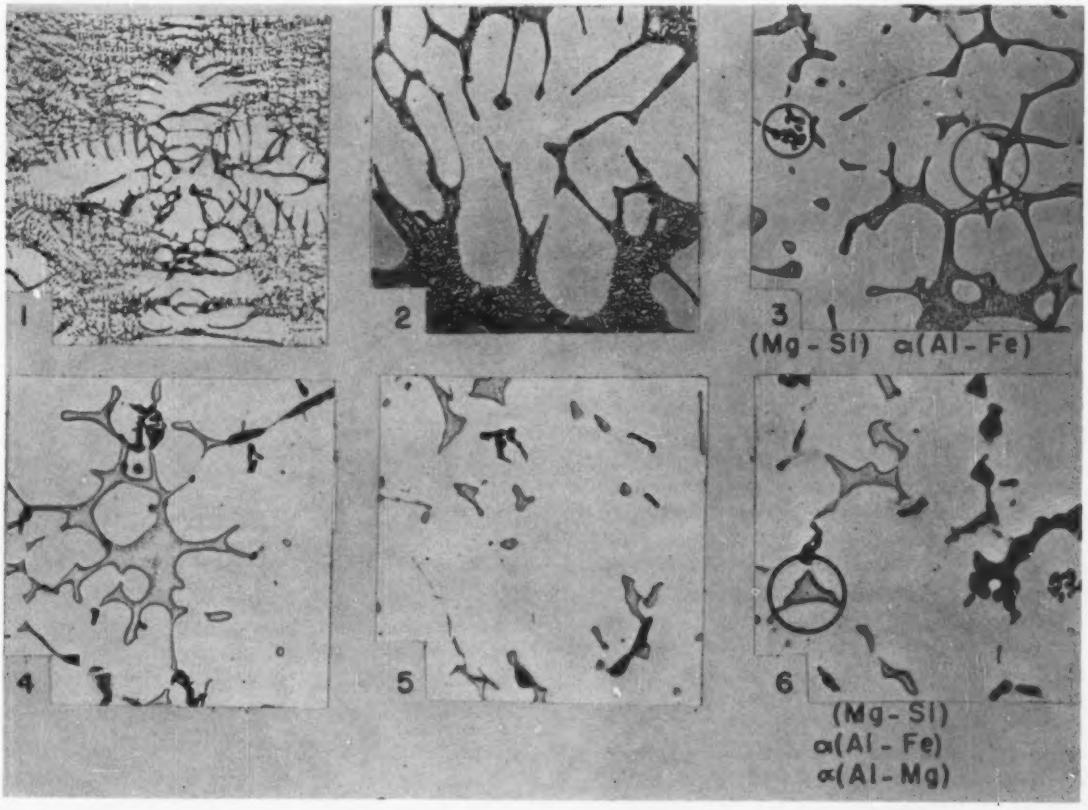
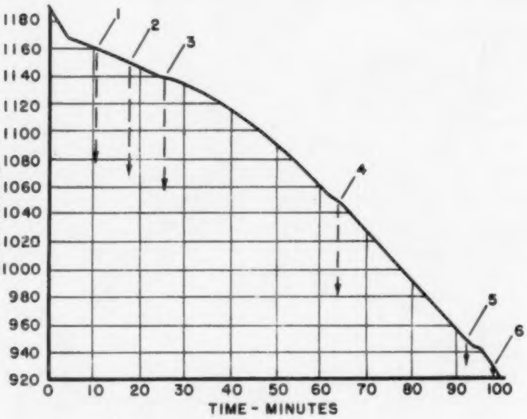


Fig. 1 — Solidification sequence for alloy 220 when slowly cooled to the indicated temperatures and water quenched. Each newly occurring constituent is circled, and its designation, plus that of all preceding constituents, is listed below the micrograph. Etch 0.5% HF. 50 ×.



composition. The manner in which several features of dendrites are affected by solidification rate has been discussed at length in the literature. Rhines and Alexander[4] showed that increasing solidification rates decreased the spacing between the arms and decreased the unit cell size. Figure 5(A) is a reproduction of a drawing from reference (4) which schematically illustrates this.

The same conclusions have been expressed by Fridlyander[7] in a recent Russian symposium on crystal growth. Figure 5(B) illustrates some curves from Fridlyander, indicating the effect of solidification rate on dendrite spacing and stem width.



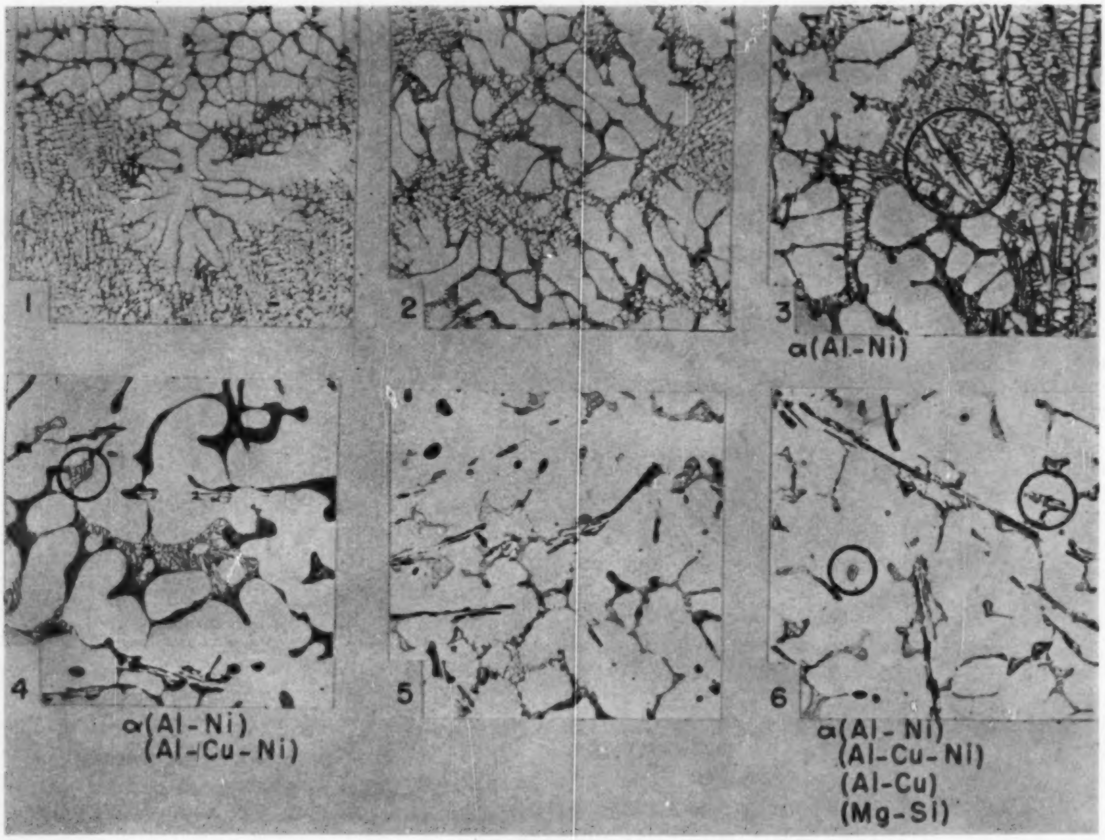
The present work substantiates the reported data concerning the refinement of the dendrite which is associated with increased solidification rate. For example, the first micrographs in Figs. 1 to 4 show the considerable difference in refinement between the dendrites formed during the initial slow cooling compared to those solidified during the water quench.

Table 2 lists numerical values for the size of dendrite cells formed during two cooling rates. As can be seen, the effect of cooling rate was considerable for all of the alloys investigated.

Alloy Composition Effect

The effect of alloy composition upon the dendrite refinement is indicated only in a broad sense in this work. As shown in Table 2, when the four alloys were cooled at the same rate, the dendrite cells were only slightly different. The small variation which did exist was such that the alloys with higher soluble element content usually contained smaller cells. However

Fig. 2 — Solidification sequence for alloy 142 when slowly cooled to the indicated temperatures and water quenched. Each newly occurring constituent is circled, and its designation, plus that of all preceding constituents, is listed below the micrograph. Etch 20% H_2SO_4 at 70 C (158 F), followed by 0.5% HF. 50 ×.



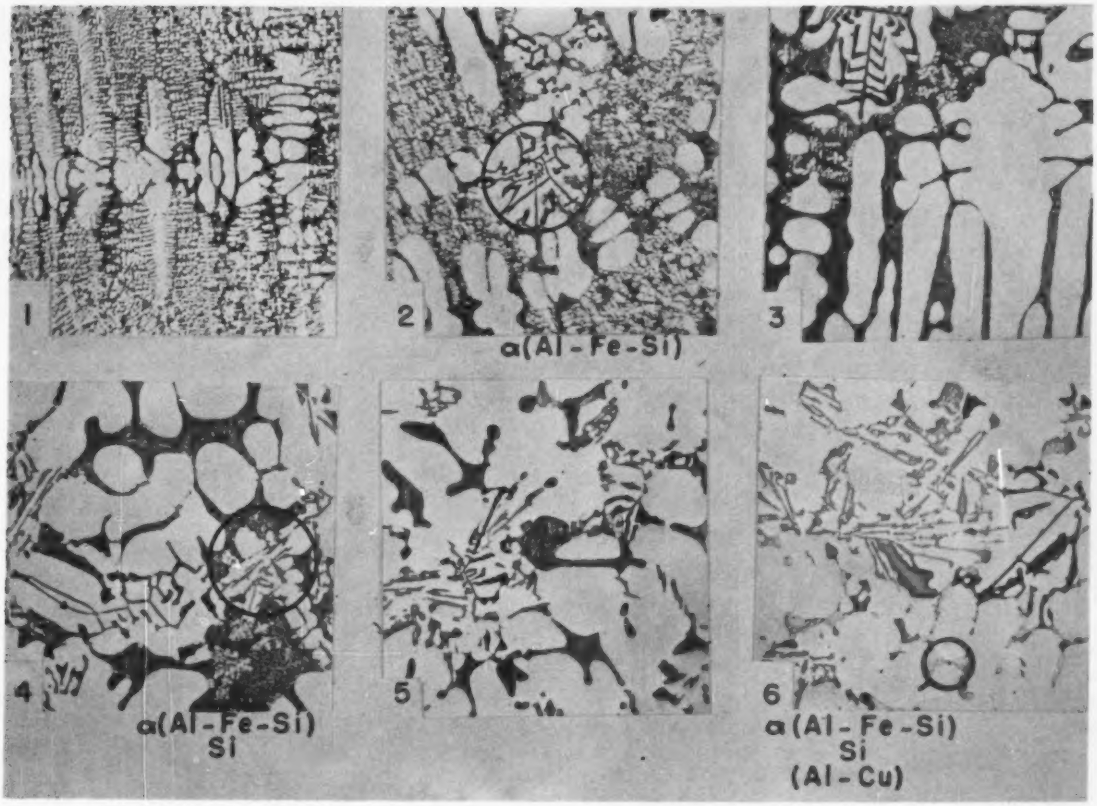


Fig. 3 — Solidification sequence for alloy 319 when slowly cooled to the indicated temperatures and water quenched. Each newly occurring constituent is circled, and its designation, plus that of all preceding constituents, is listed below the micrograph. Etch 20% H_2SO_4 at 70 C (158 F), followed by 0.5% HF. 50 ×.

the influence of solidification rate was considerably more prominent.

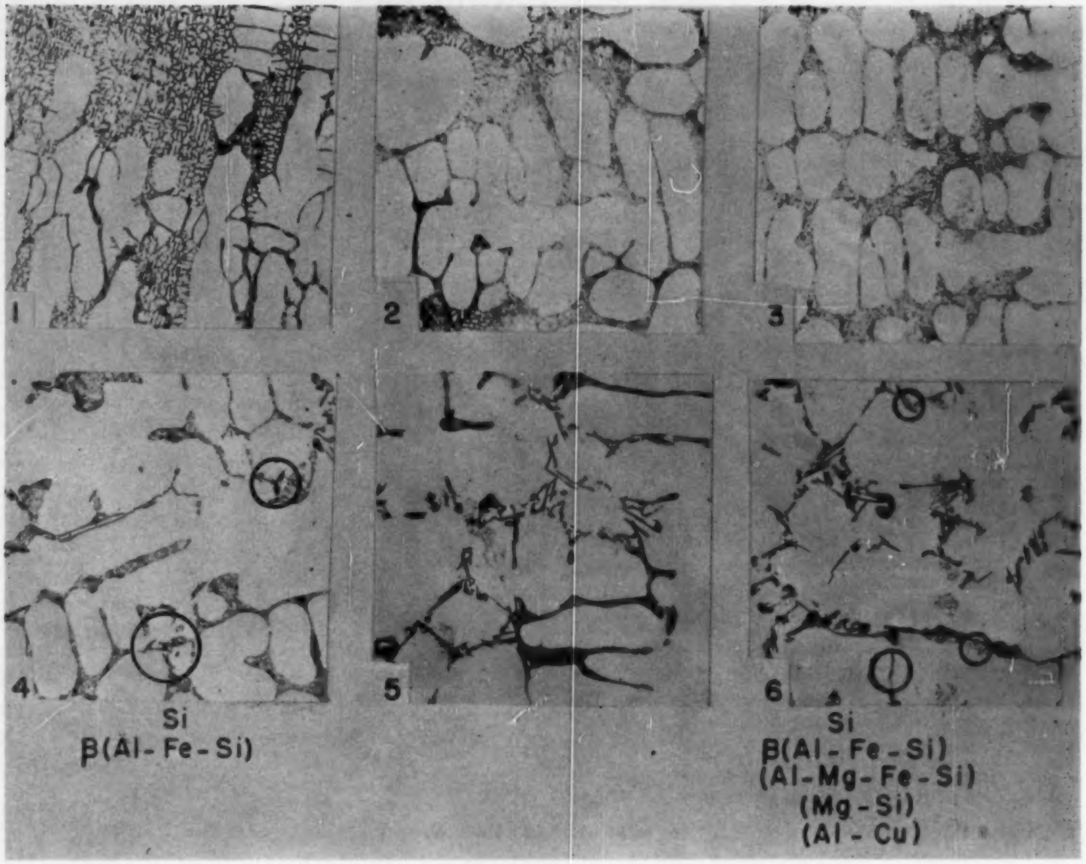
The dendrite form also depended upon alloy composition and solidification rate. An illustration of the variation in dendritic form with alloy composition may be seen by comparing the first micrographs of Figs. 1 and 3. Alloy 220 dendrites grew in an equiaxed manner with fine interdendritic channels and considerable secondary growth. In contrast, the dendrites for alloy 319 had extensive growth along the primary stem and limited secondary growth. The interdendritic channels for alloy 319 were quite broad.

This difference in form probably was associated with the availability of solid solution material in the immediate vicinity of the growing dendrite. If solid solution material is readily available, the dendrite may grow extensively about the central cell. When this is not true, a concentration of insolubles about the dendrite center forces growth along the primary stem.

The dendrite form also was influenced by the solidification rate. This effect is illustrated by the microradiographs in Fig. 6. The considerably more complex structure of the rapidly solidified dendrites is apparent. The rapidly cooled dendrites had extensive secondary and tertiary growth. In contrast to this, the slowly cooled specimen consisted of a primary stem with relatively short, broad secondary branches.

Matrix Layer Growth

To this point all of the discussion has concerned dendritic growth. The matrix also was composed of material which solidified in layers around constituents rather than in the "tree-like" form normally associated with dendritic growth. This type of solidification is illustrated in the second micrograph of Fig. 3. The



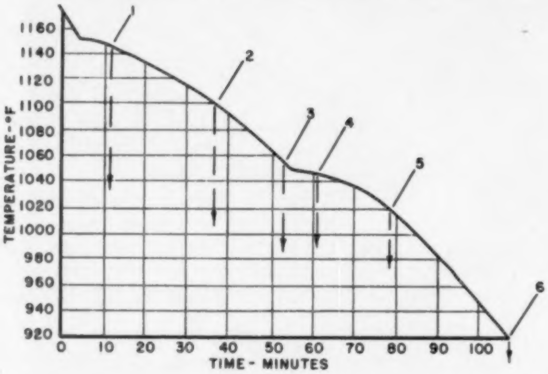


Fig. 4 — Solidification sequence for alloy 355 when slowly cooled to the indicated temperatures and water quenched. Each newly occurring constituent is circled, and its designation, plus that of all preceding constituents, is listed below the micrograph. Etch 20% H_2SO_4 at 70 C (158 F), followed by 0.5% HF. 50 ×.

α(Al-Fe-Si) constituent is shown surrounded by an aluminum solid solution layer.

Subsequent micrographs in the same series show the thickening of the layer surrounding the constituents as solidification proceeded. After the constituents are completely surrounded, the solid solution layer then begins to exhibit the usual cellular structure of dendritic growth.

Matrix Grain Formation

Another aspect of the matrix which is a part of the solidification subject is the formation of grains. The grain sizes of specimens quenched from various temperatures within the solidification zones are shown in Fig. 7. As can be seen, the grain sizes were established after a relatively small amount of cooling below the liquidus temperature. Alloys 142 and 319 had essentially the same grain size regardless of the quenching temperature. Alloys 220 and 355 reached a maximum grain growth within 20 F of the liquidus.

An explanation for the early establishment of grain size is shown in Fig. 8. The specimen in Fig. 8 was cooled slowly to 1 F below the liquidus and quenched in water. Although virtually all of the solidification occurred during the water quench, this specimen had an average grain size comparable to a specimen cooled slowly throughout its entire solidification range. Apparently, the dendrites which formed during the initial slow cooling acted as starting points for the growth of material solidified during the quench.

These initial dendrites provided such excellent nucleating points that effective new nuclei were not

developed during the quench. Therefore, the grain size was the same as though the specimen had continued to cool slowly to the solidus. In the enlarged view of Fig. 8 the growth of small dendrite cells upon the large initial cells is illustrated.

Composition-Grain Size Relationship

There appears to be a relationship between alloy composition and grain size which is connected with the dendrite form. It was shown earlier in this paper that alloys of high solid solution content solidified with dendrites which developed in a compact equiaxed manner about the nucleus. By contrast, alloys characterized by appreciable solidification near the solidus exhibited more linear growth along the primary stems. Figure 9 illustrates how these differences in dendrite growth patterns may influence the grain size.

Both specimens shown in Fig. 9 were slowly cooled until about 25 per cent solids had formed and then were quenched. The alloy with high insoluble content (319) shows dendrites with long primary stems. The solid solution type alloy (142) contained dendrites with compact growth about the central cell. Since the grain size is determined by the average dendrite size, the solid solution alloys would tend to have smaller grains than alloys with high insoluble content.

Obviously, other factors, and especially the rate of nucleation, have a considerable influence upon grain sizes. However, the effect of dendrite form upon grain

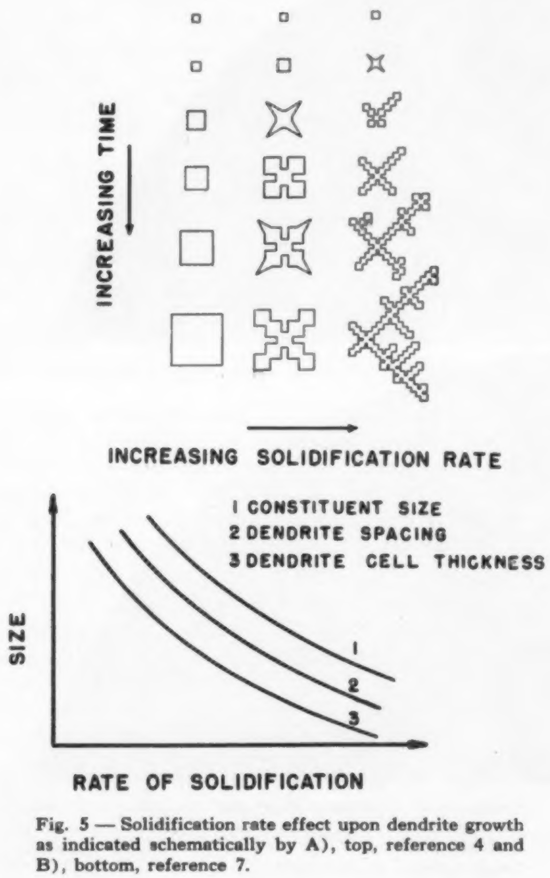


Fig. 5 — Solidification rate effect upon dendrite growth as indicated schematically by A), top, reference 4 and B), bottom, reference 7.

TABLE 2 — INFLUENCE OF SOLIDIFICATION RATE ON DENDRITE REFINEMENT

Alloy	Cooling Rate,* F/sec	Dendrite Cell Size, in.
220	3.2	0.0023
	0.03	0.0058
142	3.3	0.0022
	0.03	0.0055
319	2.5	0.0022
	0.03	0.0065
355	2.8	0.0027
	0.03	0.0070

* Measured just above liquidus.

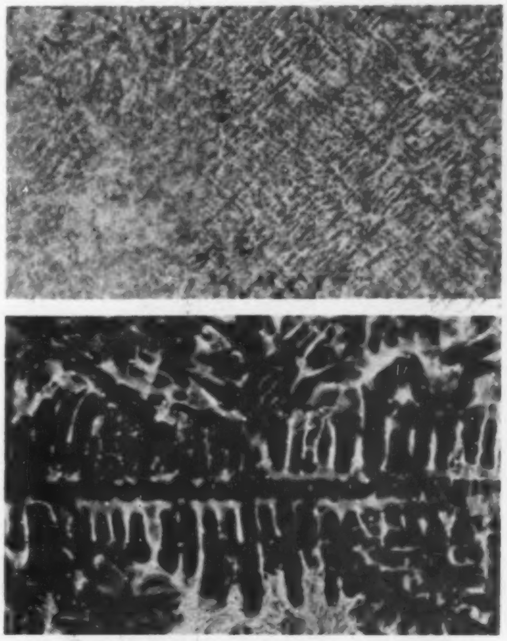


Fig. 6 — Solidification rate effect upon dendrite form as illustrated by microradiographs of 0.010 in. thick specimens of alloy 319. Specimen *A* (top) cooled at 3.0 F/sec, contains much finer celled and more complex dendrites as compared to specimen *B* (bottom) at 0.03 F/sec. Copper radiation. Dense material appears light. 25 ×.

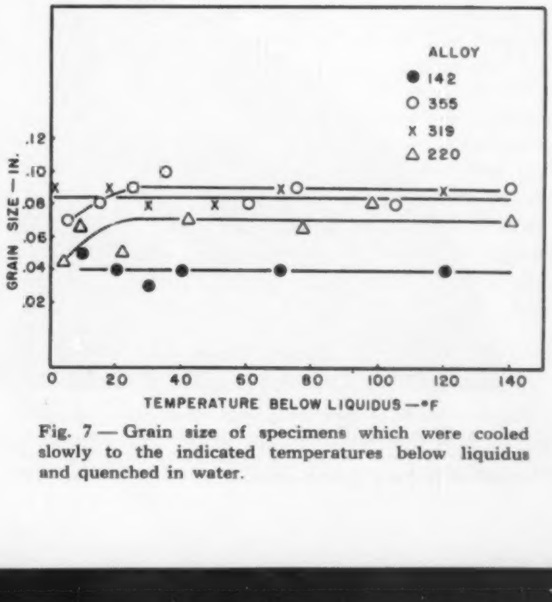


Fig. 7 — Grain size of specimens which were cooled slowly to the indicated temperatures below liquidus and quenched in water.

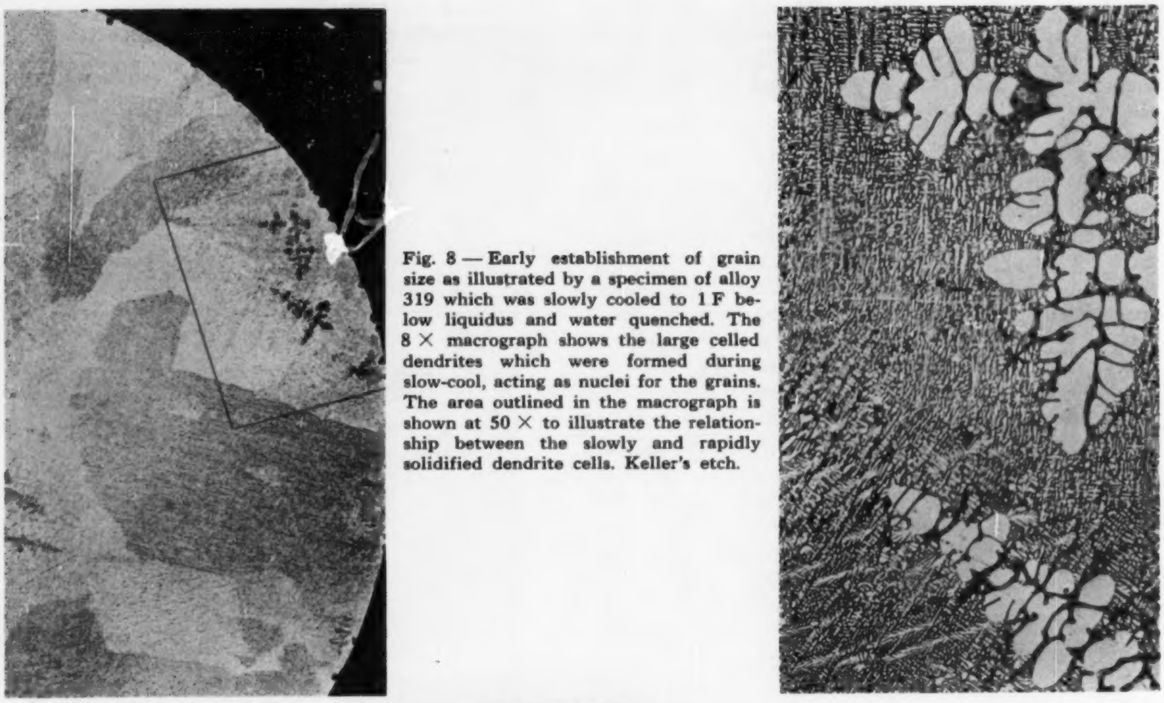


Fig. 8 — Early establishment of grain size as illustrated by a specimen of alloy 319 which was slowly cooled to 1 F below liquidus and water quenched. The 8 × macrograph shows the large celled dendrites which were formed during slow-cool, acting as nuclei for the grains. The area outlined in the macrograph is shown at 50 × to illustrate the relationship between the slowly and rapidly solidified dendrite cells. Keller's etch.

Fig. 9 — Mode of dendrite growth effect upon the grain size as illustrated by microradiographs of two alloys. Specimen *A* (top) shows the large grains formed by the extensive primary growth common to alloys such as 319. Specimen *B* (bottom) illustrates the relatively small grains formed by the compact type of dendrite growth in solid solution type alloys such as 142. Copper radiation. Dense material appears light. 10 ×.

size may help to explain the difficulty in obtaining fine grained material in alloys such as 319 and 355, even with large additions of grain refiner.

Constituents

The solidification of constituents during cooling is shown in Figs. 1 — 4. As with the matrix material, the constituents which solidified during slow cooling were distinguishable by their coarseness from the constituents which solidified during the water quench. In each figure, the micrograph in which a constituent first appears is denoted by circling the constituent. The constituent identification is listed below the micrograph along with the constituents which previously have solidified.

It should be emphasized that this paper has been concerned with the influence of solidification upon the appearance of constituents and other structural features, and that it has not attempted to substantiate the commonly accepted constituent identifications.

An important factor controlling the constituent form is the temperature within the solidification zone at which the constituent solidifies. Constituents which solidify near the solidus generally are restricted in growth by the material already solid. Constituents which solidify near the liquidus have considerably more freedom of growth.

Examples of constituents which solidify toward the end of solidification include α(Al-Mg) in alloy 220 and (Al-Cu) in alloys 142, 355 and 319. These constituents usually were of a shape similar to the liquid pools from which they solidified. Since these pools were relativtly small even in slowly cooled material, constituents generally were small.

Examples of high melting temperature constituents are α(Al-Ni) in alloy 142 and α(Al-Fe-Si) in alloy 319. Since these constituents began solidification prior to the establishment of an interdendritic network, growth was unrestricted. As a result, these constituents were free to become quite gross during slow solidification.

Intermediate Temperature Solidification

Some constituents solidify at temperatures where a dendritic network has formed, but large pools of liquid metal are still present. Examples of constituents which solidify at these intermediate temperatures are (Mg-Si) and α(Al-Fe) in alloy 220, (Al-Cu-Ni) in alloy 142, and the Si constituent in alloy 319. These constituents generally are similar to the high temperature constituents with respect to growth.

An example of the influence which this factor has upon the constituent form is illustrated by the Si constituent in alloys 319 and 355. In alloy 319 (Fig. 3) the silicon constituent solidified from large molten pools of metal. Therefore, the silicon particles were relatively gross aggregates. In alloy 355 (Fig. 4) the silicon particles did not begin solidifying until only small interdendritic channels remained. In this case, the silicon particles usually formed small groups of needles.

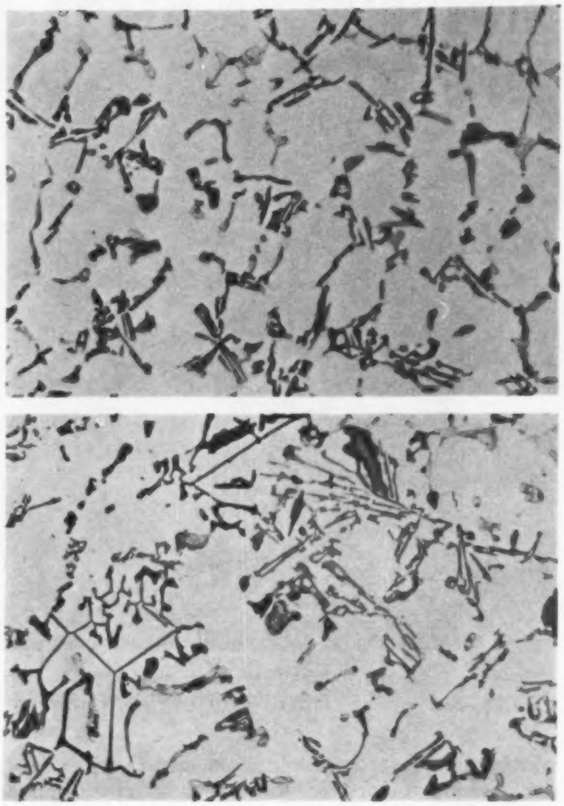


Fig. 10 — Solidification rate effect upon constituent size. *A* (top) was solidified at 2.5 F/sec (150 ×), while *B* (bottom) was solidified at 0.03 F/sec (50 ×). The magnification of the micrographs has been adjusted so the fine matrix appears to be the same degree of refinement. Alloy 319. Etch 20% H_2SO_4.

The rate of solidification also may affect the refinement of the constituents. The degree of refinement associated with increased solidification rates varies in a general manner with the temperature at which the constituents solidify. The constituents which solidify during the earlier stages are more affected by changes in rate than are the constituents that solidify later.

Rapidly cooled and slowly cooled specimens of alloy 319 illustrate this effect in Fig. 10. The magnifications were adjusted in this figure so that the dendritic matrix appeared to have the same level of refinement for both specimens. Despite the magnification adjustment, the high temperature constituent, α(Al-Fe-Si), of the slowly cooled specimen was considerably larger than the same constituent in the more rapidly cooled specimens. The Si constituents, which solidify at an intermediate range, were slightly larger. The (Al-Cu) constituents, which solidify near the solidus, were approximately the same in both micrographs.

Feeding and Hot Cracking

Constituent material has been credited with having an influence upon feeding and hot cracking. The

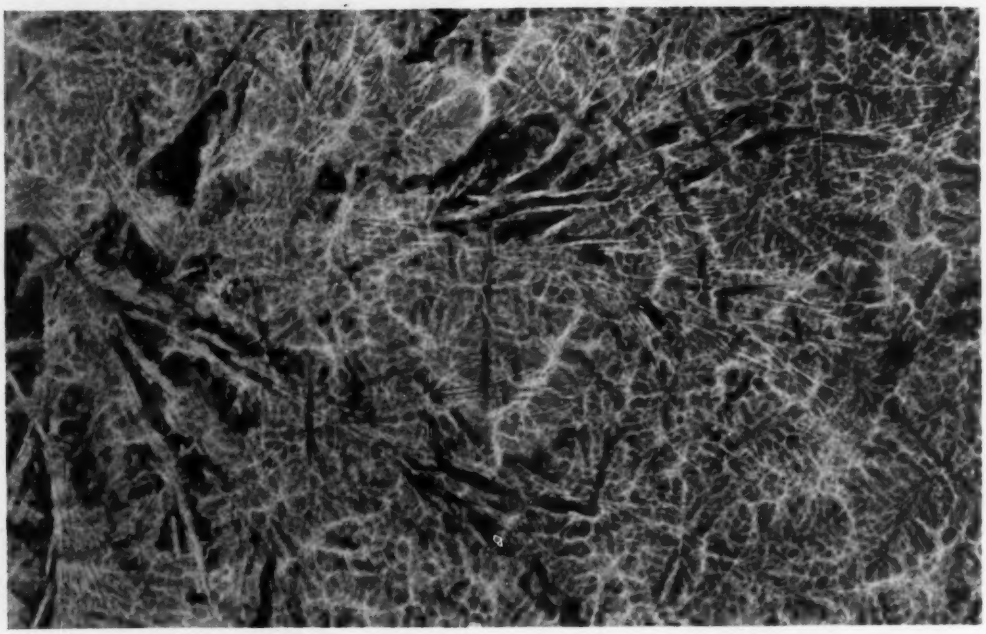


Fig. 11 — Association of voids with the α(Al-Ni) constituents in alloy 142 as shown by a microradiograph of a 0.010 in. thick section. Voids appear dark. 25 ×.

observation that the high temperature constituents are enveloped in solid solution immediately upon solidifying adds credulity to this. The solid solution envelope would be expected to increase the constituent size and to weld quite easily to dendrite arms. This would tend to form a coherent network earlier or a stronger network. The relationship between the temperature at which this network formed, and the strength of the resulting network, would determine whether the constituents increased or decreased the resistance to hot cracking.

The presence of an envelope about the constituents might influence feeding in that the larger size would present a considerably more effective dam to the passage of feed metal. An illustration of this is shown in Fig. 11. The microradiograph of alloy 142 shows the porosity associated with the α(Al-Ni) constituents in a slowly cooled specimen. It will be noted that the voids appear to be more closely related to the enveloped α(Al-Ni) constituents than to the primary dendrites. The action of the solid solution envelope in increasing the effective size of the constituents also is apparent in Fig. 11.

CONCLUSIONS

1) The matrix of the alloys investigated was formed by growth of primary dendrites and by deposition of solid solution material around constituents.
2) The dendrites were refined considerably by increasing the solidification rate. The effect of alloy variation upon the dendrite cell size was slight.
3) The dendrite form depended upon alloy content and solidification rate. Alloys in which large amounts of solid solution material were available immediately below the liquidus formed compact dendrites. Alloys containing considerable constituent material formed dendrites developed mostly along the primary stems. For all alloys, the amount of secondary and tertiary growth increased with increasing solidification rates.
4) The grain size was established immediately below the liquidus for all alloys. The influence of alloy composition upon the form of the dendrite, as mentioned in conclusion (3), also tended to reduce the size of the grains for solid solution type alloys as compared with alloys having appreciable solidification near the solidus.
5) Constituents which solidified near the liquidus tended to be larger than constituents which solidified near the solidus. They also changed size more readily with variation in solidification rate.

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DENSITY—SAND GRAIN DISTRIBUTION EFFECT ON PHYSICAL PROPERTIES

by T. W. Seaton

ABSTRACT

The AFS Sand Division Basic Concepts Committee work on sand density is presented, showing results of several researchers working with various sands. Sieve fraction densities, sand distribution effect on density and grain distribution effect on density and physical properties are presented.

INTRODUCTION

This report has been prepared in order that the work of the AFS Sand Division Basic Concepts Committee, on density,* may be summarized, definite conclusions resulting from this study be listed and an analysis made of the data collected.

Some of the data referred to in this report have been published, but a great deal of significant data have not. Feeling that it is time to bring all of these data together in order that much valuable time on the part of committee members shall be published, the writer has taken the liberty of using this data in a manner perhaps not originally intended but with interesting results.

While the committee has not as yet standardized on a method of density determination for unbonded sands, this was not deemed necessary to this paper.

The following phases will be covered:

1) Density of sieve fractions of clay free sands.
2) Sand distribution and its effect on density of clay free sands.
3) Effect of grain shape on density of clay free sands.
4) Effect of distribution on density and physical properties of clay, water and silica mixtures.

DENSITY OF SIEVE FRACTIONS OF CLAY FREE SANDS

The majority of this work was reported by Heine and Seaton,[1] and it is only necessary to show here the conclusions resulting from this investigation.

1) Density of sieve fractions decreases as fineness increases, regardless of the method used for compaction when high purity silica sand grains are used.
2) The density of sieve fractions increases as fineness decreases, regardless of the method used for compaction.
3) Presence of iron oxides or other heavy minerals in sands has the effect of increasing density of the fractions beyond the densities obtained for comparable fractions of relatively pure sands.
4) Regardless of the size and shape of the unbonded sand grains, the relationship between compacting energy and density remains the same. This, of course, is true of sands relatively free of non-silica particles.
5) As fineness of the fractions increased, maximum density was achieved with less applied jolting energy.
6) After maximum density was reached, additional application of energy resulted only in a reduction of density of the mass.
7) Vibration resulted in higher densities than those obtained by jolting or ramming.
8) This study was not intended to evaluate the desirability of using either high or low density sands in foundry operations.
9) The curves relating density to sieve fraction (Figs. 4 through 8) provide a profile view of the purity of the sand and its packing behavior. Any marked deviation from the curve for pure silica particles indicates an important change in the sand such as purity, particle shape or porosity.

SAND DISTRIBUTION AND ITS EFFECT ON DENSITY OF CLAY FREE SANDS[2]

1) Thirteen sands were designed for this study, and working samples were prepared by blending various sieve fractions to achieve the desired analysis.
2) Eight commercially available sands ranging from 31 to 80 AFS Grain fineness number (Gfn) were obtained and subjected to the same studies as those sands used in Part 1.

Design Sands

Table 1 shows the design and actual analysis of the 13 synthetically prepared distributions.

For sands 1 through 7, the U.S. Series Sieve No. 70 was used as the pivotal sieve, and the distribution was spread using it as the "peak" sieve. The purpose

*Density as referred to in this paper is "bulk density" of the sand mass.

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here was to determine the effect of uniformly broadening the distribution on both sides of the "peak" or pivotal sieve. This gave, as the distributions broadened, sands similar to those in use in foundries.

The jolted dry density data obtained for these sands are shown in Table 2.

It can be seen upon examination of the data that

TABLE 1 — DESIGN ANALYSIS

Sand No.	1	2	3	4	5	6	7	8	9	10	11	12	13
U.S. Series Sieve No.						% Retained on							
20													5
30							5					10	5
40					5	5	15				20	20	20
50			50	30	30	15	30				40	30	30
70	100	50	50	40	30	30	30	40	40	40	40	40	40
100		50		30	30	30	15	40	30	30			
140					5	15	5	20	20	20			
200						5			10	5			
270										5			
Pan													

Actual Analysis

Sand No.	1	2	3	4	5	6	7	8	9	10	11	12	13
U.S. Series Sieve No.						% Retained on							
20												0.09	4.81
30			0.60				4.90					9.65	4.28
40	0.04	2.40	49.74	0.30	5.20	5.6	15.30	0.20	0.10	0.09	19.93	20.84	19.53
50	2.60	45.19	45.54	29.30	29.90	16.2	29.70	1.90	1.70	1.59	39.77	30.11	30.24
70	93.90	45.09	3.80	37.45	28.15	27.8	27.40	34.74	34.23	35.36	35.97	35.27	36.75
100	3.30	7.20	0.30	27.95	26.95	26.4	15.20	37.03	28.02	28.27	3.70	3.44	3.74
140	0.14	0.10	0.20	5.00	9.40	17.6	7.20	23.52	23.02	22.67	0.30	0.28	0.35
200	0.04	0.02			0.40	5.8	0.30	2.40	12.11	7.09	0.10	0.19	0.08
270	0.01					0.4		0.10	0.70	4.79	0.10	0.09	0.08
Pan	0.01					0.2		0.10	0.10	0.09	0.10		0.08
AFS Gfn	50.5	62.5	48.8	55.1	56.4	67.7	49.4	71.5	79.1	80.6	43.4	41.0	41.1

as the distribution is broadened around the pivotal sieve, the density of the sands increases. It is reasonable to expect that this would hold true regardless of the choice of the pivotal sieve. If the pivotal sieve chosen is coarser than the one used in this work, the densities will run higher than those shown in Table 2. If the pivotal sieve chosen is finer than the one used in this work, the densities will be lower. This, of course, applies to sands having distributions comparable to those used in this work.

For sands 8 through 13, the U.S. Series Sieve No. 70 was again used as the pivotal sieve but the distribution was broadened one sieve at a time, first to the fine side and then to the coarse side.

TABLE 2 — DENSITY DATA JOLTED DRY DENSITY (LB/CU FT)

Sand No.	1	2	3	4	5	6	7
No. of Jolts							
5		94.37	95.82	97.57	99.46	99.34	101.94
10	94.35	95.20	96.83	98.26	100.00	100.23	103.06
15	95.00	95.87	97.18	98.79	100.54	101.14	103.63
20	95.65	96.01	97.69	99.13	101.10	101.89	104.21
25	95.98	96.11	97.86	99.80	101.46	102.06	104.21

Sand No.	8	9	10	11	12	13
No. of Jolts						
5	95.96	96.31	97.52	97.06	98.63	98.86
10	96.46	98.07	98.60	98.06	99.30	99.68
15	96.63	98.62	99.14	98.74	99.82	100.02
20	96.98	98.80	99.51	99.08	99.98	100.53
25	96.98	99.17	99.70	99.25	100.33	100.53

As the distribution was broadened to the fine side, the density, under all conditions of jolting, increased. As the distribution was increased to the coarse side, the density also increased.

High Densities

The fact that the higher densities were obtained when the distribution was broadened to the coarser side is explained by the fact that coarser sands will result in higher densities than the finer sands. This was proved in the studies of densities of sieve fractions.[1] Coarser sands have larger and fewer voids than finer sands which, though the voids are smaller, contain many more voids. This then, accounts for the higher densities obtained with coarse sands.

In Table 3 is shown the sieve analysis of eight commercially available sands used in this study. Table 4 shows the density data obtained on these eight sands. The purpose of this phase of the investigation was to show that basically, as the AFS Gfn of sands increase, the density decreases. While sand 14 did not follow the expected pattern, this can be explained by the fact that its distribution was not as broad as the distribution of sand 15. Had the distributions been similar, sand 14 would have had the highest density. Reference to the data show that as the Grain Fineness number increases, the density decreases. For sands of similar distributions this may be expected.

In conclusion, the following two statements may be applied to clay-free sands:

1) There is direct relationship between AFS Gfn and median grain size, and it is this "median size" which determines whether the density of a given sand will fall in the high or low range.
2) For a sand having a given "median size," density may be increased by broadening the distribution. The broadening may be done to either the fine or coarse side of the distribution or in both directions simultaneously, and a sand of higher density will result. Broadening to the coarse side has a greater effect on density than boadening the distribution to the fine side.

GRAIN SHAPE EFFECT ON DENSITY[3]

The final phase of the study of density of clay free sands was to determine the effect of grain shape on density.

Three sands of round, subangular and angular shape were prepared for this investigation. The sieve

TABLE 3 — COMMERCIALLY AVAILABLE SANDS — SIEVE ANALYSIS

Sand No.	14	15	16	17	18	19	20	21
U.S. Series Sieve No.								
20	2.2	0.8						
30	24.9	8.6	2.1	1.05				
40	47.4	26.8	18.3	10.50	2.8	2.3	1.2	0.2
50	19.8	30.6	31.6	26.05	21.5	14.9	10.4	2.5
70	4.9	17.4	22.4	29.63	34.8	29.2	30.2	6.5
100	1.5	10.2	15.4	19.75	24.3	30.7	35.9	46.7
140	0.4	4.7	7.7	9.77	12.4	17.1	17.4	32.2
200		1.0	2.0	2.63	3.4	4.8	4.2	9.6
270	0.9	0.2	0.4	0.52	0.7	0.9	0.6	2.1
Pan		0.1	0.1	0.10	0.1	0.1	0.1	0.2
AFS Gfn	31.3	44.7	52.1	57.2	62.7	68.7	69.5	80.4

analysis and densities obtained for these sands are shown in Table 5.

From the data shown in Table 5, it may be concluded that rounded grained sands develop highest densities, angular grains next and subangular grains the lowest. It is reasonable to expect that the relationship will hold true regardless of the distributions of the sands, as long as when they are being compared the distributions are similar.

TABLE 4 — JOLTED DRY DENSITY (LB/CU FT)

Sand No.	14	15	16	17	18	19	20	21
No. of Jolts								
5	106.40	107.67	106.75	105.82	104.40	103.00	102.43	101.24
10	108.18	109.04	108.33	107.38	106.29	104.66	103.93	102.77
15	108.80	110.03	109.14	108.36	107.27	105.81	105.09	103.54
20	109.62	110.64	109.96	108.93	108.06	106.39	105.29	104.33
25	109.84	111.25	110.58	109.37	108.66	106.97	105.88	104.73

Throughout the work on density, comparisons have been made between high and low density sands. It is important to keep in mind that the densities referred to are those of clayfree sands and not bonded sands. The studies do not make any attempt to recommend either high or low density sands in actual foundry practice. This is the subject of work to be conducted later.

DISTRIBUTION EFFECT ON DENSITY AND PHYSICAL PROPERTIES OF SAND, CLAY AND WATER MIXTURES

During the work on density of clay-free sands two investigators[3-4] collected additional data on sand, clay and water mixtures. These data have provided some extremely useful information relating density, sand distribution and physical properties. In addition, two other researchers[5-6] have recorded data on sands of varied distributions.

The writer has taken the liberty of using the data provided by these researchers to arrive at some interesting conclusions. The value of these data is especially enhanced by the fact that it was obtained by four different researchers working under different conditions and with different objectives in mind.

In Table 6 are shown the data collected by Rose,[3] Pedicini[4] and Rowell.[6] Only the data obtained by these researchers pertinent to this paper are shown.

The first data to be considered were prepared by Rose. Two conditions are shown here— 1) the comparison of physical properties of a broad and narrow distribution of a rounded grained sand, and 2) the comparison of physical properties of a broad and narrow distribution of a subangular grained sand.

Physical Properties Obtained

The physical properties obtained for these sands are shown below the sieve analysis for these sands. All four of these sands were mulled, bonded and tempered in the same manner.

By comparing the physical properties of the narrow and broad distributions, it can be seen that for both round and subangular sands, the broad distribution gave the higher physical properties.

A comparison of the properties of the round and subangular sands shows that round grained sands gave higher physical properties than subangular grained sands.

TABLE 5 — GRAIN SHAPE EFFECT ON DENSITY

U.S. Series Sieve No.	Angular	Subangular	Round
40	3.2	1.9	2.6
50	88.6	87.5	86.7
70	8.2	10.6	10.6
100	—	0.1	0.1
AFS Gfn	40.5	40.9	40.8
Specific Gr.	1.445	1.403	1.588
% Solid	54.5	53.0	59.9

The fact that permeability for the round grained sands is lower than for subangular is explained by the fact that rounded grains will compact more tightly than subangular grained sands under the same compacting energy.

Rowell prepared two sands of similar AFS Grain fineness number, but with considerable difference in the distributions. An examination of the data shows that the more broadly distributed sand developed the higher physical properties. Both sands were mulled, bonded and tempered alike.

Other Studies

Pedicini studied a wide range of sands which were commercially available. His primary interest was the study of density. However, he did report some data on bonded sands, (clay and water) and two of the sands are shown in Table 6. The AFS Grain fineness

TABLE 6 — DATA FROM OTHER RESEARCHERS

	ROSE				
U.S. Series Sieve No.	Rounded Grain Narrow	Rounded Grain Broad		Subangular Grain Narrow	Subangular Grain Broad
20					
30					
40	1.2	0.2		1.2	0.9
50	80.6	4.2		80.4	9.8
70	18.2	29.0		18.8	32.7
100		48.2			39.4
140		12.4			13.7
200		3.8			3.3
270		2.0			0.3
Pan		0.2			0.1
AFS Gfn	41.7	72		41.9	67
Green Compr.	6.8	7.8		5.1	5.4
Mold Hardness	85	85.5		85	84
Green Perm.	350	92		435	148
Dry Compr.	68	100		50	60
Green Shear	2.2	3.15		1.5	2.1
Hot Strength at 2000 F	150	305		150	240

U.S. Series Sieve No.	ROWELL Narrow	ROWELL Broad		PEDICINI Narrow	PEDICINI Broad
20					0.22
30		1.2			2.68
40		12.1			13.70
50	1.2	21.7		34.12	33.70
70	30.0	19.6		48.50	31.20
100	52.4	15.5		15.02	12.28
140	13.8	15.8		2.26	3.34
200	2.2	9.9			1.42
270	0.4	3.1			0.72
Pan		1.1	Unbonded		0.76
AFS Gfn	70	74	Dry % Solid	51.7	51.4
Green Compr.	6.6	8.08	Bonded %	61.9	66.7
Mold Hardness	87	85	Solid 5 Rams	56.5	56.5
Green Perm.	100.5	69.7	Green Compr.	6.7	11.9
Hot Strength at 2000 F	230	303			

TABLE 7 — DATA FROM McQUISTON

Distribution No.	% Retained on 1	2	3	4	5	6	7	8	9
U.S. Series Sieve No.									
20									
30		1.5	0.8						
40	15.7	18.7	15.1						
50	50.5	34.2	21.0	12.9	12.9	14.1			
70	24.2	21.8	17.9	51.0	32.7	21.5			
100	7.8	10.2	14.0	25.6	32.4	21.4	9.4	14.4	15.9
140	1.2	3.5	9.0	6.0	11.6	17.8	48.7	37.0	22.5
200	0.3	1.9	10.8	3.5	4.9	12.3	30.2	25.8	19.5
270		0.9	4.8	0.6	1.4	4.3	6.4	10.6	8.2
Pan	0.2	2.0	4.7	0.4	2.1	5.0	4.4	11.4	18.9
AFS Clay	0.1	5.2	2.0		2.0	3.6	0.9	0.8	14.6
Total	100.0	99.9	100.1	100.0	100.0	100.0	100.0	100.0	100.0
AFS Gfn	44.73	54.48	81.20	61.88	73.21	93.35	124.68	139.72	157.68

number of the two sands is identical. A difference in green compression is shown. The more broadly distributed sand shows the higher green compressive strength. Green compression was the only physical property other than density reported by Pedicini.

In Tables 7 and 8 are recorded some of the data prepared by McQuiston,[5] and it is quite comprehensive. Shown here are three series of distributions

TABLE 8 — DATA FROM McQUISTON

Distribution No.	Squeeze Pressure, psi	Moisture. %	Compressive Strength, psi	Permeability	Hardness	Specimen Weight, gms.
1	50	5.7	3.9	290	69	158.0
	100		4.3	237	74	163.2
	150		4.1	213	76	165.6
	200		4.4	202	78	166.6
2	50	5.2	4.1	196	72	165.0
	100		5.2	148	78	168.5
	150		6.2	126	81	171.0
	200		6.7	112	82	173.0
3	50	5.0	4.0	76	73	167.0
	100		6.4	54	79	170.6
	150		7.7	47	82	172.9
	200		8.5	45	84	175.0
4	50	5.2	3.3	142	72	158.2
	100		3.7	117	77	162.0
	150		3.8	108	78	164.7
	200		4.0	103	78	165.9
5	50	5.2	4.1	106	74	166.2
	100		5.2	82	78	169.1
	150		5.9	71	80	171.3
	200		6.2	67	82	172.8
6	50	5.2	4.5	66	74	164.5
	100		5.6	53	80	168.8
	150		6.5	46	83	171.2
	200		7.2	45	84	173.3
7	50	5.3	3.1	59	66	144.9
	100		3.8	50	73	148.4
	150		4.2	46	75	151.3
	200		4.5	44	77	152.9
8	50	5.2	3.0	52	65	143.9
	100		3.7	45	71	147.8
	150		4.3	41	75	150.7
	200		4.6	38	76	152.8
9	50	5.2	4.9	28	75	154.4
	100		7.1	12	82	162.1
	150		9.1	9	85	166.8
	200		10.2	8	87	170.3

prepared by McQuiston. Others were prepared and are reported in his paper, and the relationship to be described below holds true in all cases.

In the case of McQuiston's data, for each set of sands, the "peak" sieve remains the same and the distribution is broadened to either side.

The sands were mulled, bonded and tempered in the same manner.

In series 1, the peak sieve is the U.S. Series Sieve No. 50. In series 2, the peak sieve is the U.S. Series Sieve No. 70 and in series 3, the U.S. Series Sieve No. 100 is the peak sieve.

Data were taken at different squeeze pressures which resulted in varied mold hardness readings on the 2 x 2 specimens.

By comparing green compressive strengths of the three sands in each series at the same mold hardness, it can be seen that the sands of broadest distribution give the higher green compressive strengths.

This relationship holds true regardless of the "peak" sieve involved. It does appear, however, that the difference is not as great when sands of relatively large AFS Grain fineness numbers are considered. However, a difference still does exist.

CONCLUSION

While the physical properties of the sands herein reported have not been studied under all conditions and in all temperature ranges, it does appear that there is enough information to indicate a trend.

In the writer's opinion, additional data should be obtained covering all conditions of use, range of temperatures and use of various bonding materials.

Based on this study, the following conclusions may be made:

1) When comparing sands of similar AFS Grain fineness number, the sand with the broadest distribution will develop the higher physical properties when the sands are mulled, clay bonded and tempered to the same conditions.

2) When sands with the same "peak" sieves are compared, the sand with the lowest peak (broadest distribution) will develop the higher physical properties when they are mulled, clay bonded and tempered to the same conditions.

ACKNOWLEDGMENT

The writer wishes to thank the members of the Basic Concepts Committee of the AFS Sand Division for their contributions and assistance in the preparation of this paper.

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6. V. M. Rowell, "Recent Developments in Sand Testing with Reference to Steel Castings," *Foundry*, July, 1959.

news and views

Exposition Draws Foundrymen to Metalcastings Showplace

■ Why can exhibitors at the 1960 AFS Castings Congress & Exposition, May 9-13 at Philadelphia, see more foundrymen in the shortest time at the least cost? *Because*, says AFS Exhibit Manager W. N. Davis, "15,-000 *foundrymen from the United States, Canada, Mexico and abroad will be present to hear the latest technical research papers and to see the newest equipment and processes designed for the coming decade.*"

Proof of this statement may be found in the attendance records developed during the 1958 meeting in Cleveland. Executives, superintendents, technicians, foremen and other foundry personnel from every state in the union participated in technical sessions and visited more than 200 exhibits.

In addition, visitors were registered from Austria, Belgium, Brazil, Burma, Canada, Costa Rica, Cuba, England, France, Germany, Hawaii, Japan, Mexico, the Netherlands, Philippine Islands, Puerto Rico, Sweden and Switzerland.

What are the advantages of Philadelphia as a convention town? Davis points out that Philadelphia was the site of the first AFS meeting in 1896 and host again in 1907, 1919, 1928, 1934 and in 1948 when it drew more foundrymen than any exposition east of Cleveland. Philadelphia is a major foundry activity center, has good housing facilities and is within easy commuting distance of major east coast and midwestern cities.

The Philadelphia Convention Hall-Auditorium has many advantages for the foundry exhibit. More than 100,-000 sq ft of display area is available with ample height, good lighting, maximum floor-load support, complete air-conditioning and a first-class restaurant. In addition, the hall has excellent truck loading facilities plus railroad siding which runs directly to the auditorium.

Concurrent with the Exposition, and in the same hall, will be the AFS Castings Congress. More than 100 technical papers on all phases of foundry technology will be presented in this five-day "metalcasting week"—attracting the finest technical talent in the industry. The combining of the Castings Congress and Exposition brings together the top production and research personalities, making Philadelphia May 9-13 the focal point of the castings industry.

Nominate Dunbeck and Hunt As Officers for Society

■ Norman J. Dunbeck, Vice-Pres., Industrial Minerals Div., International Minerals & Chemical Corp., Skokie, Ill., has been nominated President of the American Foundrymen's Society to take office next May. Albert L. Hunt, Executive Vice-Pres. of Superior Foundry, Inc., Cleveland, was selected as the Society's new Vice-President by the Nominating Committee which met December 7. Both will serve terms of one year.

The committee also nominated six new National Directors of the Society to serve terms of three years each, as follows:

Robert R. Ashley, Foundry Mgr., Detroit Controls Div., American Radiator & Standard Sanitary Corp., Bridgeport, Conn.

Donald E. Webster, Foundry Supt., American Laundry Machinery Co., Rochester, N. Y.

Walter E. Sicha, Chief of Cleveland Research Div., Aluminum Company of America, Cleveland.

James T. Moore, Vice-Pres., Wells Mfg. Co., Skokie, Ill.

Warren C. Jeffrey, Prod. Development Mgr., McWane Cast Iron Pipe Co., Birmingham, Ala.

Hubert Chappie, Foundry Supt., National Supply Co., Torrance, Calif.

Dunbeck is the Society's present Vice-President and has been associated with International Minerals since 1952. Hunt, formerly Vice-President of Operations for National Bearing Div., American Brake Shoe Co., St. Louis, with whom he was associated for 24 years, was recently named executive officer of Superior. He served as a national director of the Society 1951 to 1954.

Election of the Society's new officers and directors will take place at the Castings Congress and Exposition to be held May 9-13 in Philadelphia. Additional nominations can be made up to 45 days prior to the annual meeting on written petition signed by at least 200 members.

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D. F. Lunsford

H. B. Voorhees

T. E. Smith

R. R. Deas, Jr.

METAL CASTINGS CONFERENCE

The 10th Annual Purdue Metals Casting Conference attracted over 170 midwestern foundrymen to Purdue University on Oct. 29 and 30. The technical speakers brought the conferees up to date on the latest technical and operating practices. Twelve committeemen assisted Conference Chairman Dallas F. Lunsford, Perfect Circle Corp., Hagerstown, Ind., Program Chairman Howard B. Voorhees, Mishawaka, Ind., and Asst. Program Chairman Thomas E. Smith, Central Foundry Div., GMC, Danville, Ill.

John W. Hicks, assistant to the president, Purdue University, officially welcomed the foundrymen attending this 10th Purdue Metals Casting Conference. On behalf of the University he invited the Conference to continue to use the extensive facilities of the new Memorial Center for future meetings.

R. R. Deas, Jr., AFS regional vice-president, extended the official thanks of the Society to the University and welcomed the foundrymen to the Conference. Deas concluded his remarks by saying, "We are living today in the 'jet age,' 'space age,' 'missile age' and 'atomic age'—all connoting speed and change. To meet these changing times, foundrymen must constantly study, read, exchange ideas, visit plants and attend technical meetings, such as this Metals Casting Conference."

■ PRACTICAL APPLICATION OF THE CO_2 PROCESS/**William E. Jones,** Lester B. Knight & Associates, Chicago . . . (Because Jones was out of the country his paper was presented by Sam Hodler, Golden Foundry, Columbus, Ind.) Chief merit of CO_2 process is its ability to harden cores and molds ready for use in 8 to 15 seconds. A one-inch facing of sodium silicate-bonded sand backed up with green sand is a practical economy for the CO_2 process. A typical mix contains 4 per cent sodium silicate costing $0.328 per 100 lb of sand and one lb of CO_2 costing $0.05. Facing can be shoveled directly onto pattern without riddling because it has such excellent flowability. CO_2 process cores and molds have many advantages such as . . . increased metal yield . . . uniform casting weight . . . faster delivery . . . use of knife gates . . . increased coremaking capacity . . . elimination of core driers and plates . . . no oven baking needed. ■ ■ ■

■ MELTING OF COPPER BASE ALLOYS/**F. L. Riddell,** H. Kramer Co., Chicago . . . Products of combustion are principal source of gas contamination in brass and bronze. Both O_2 and H_2 can co-exist in copper-base alloys. When one is high the other is low. To determine whether furnace atmosphere is oxidizing or reducing, hold a piece of zinc in the flame. If it turns black, furnace is operating reducing; if zinc becomes yellow, atmosphere is neutral; and if test piece changes to bluish white, conditions are oxidizing. Presence of oxides in metal reduce fluidity and increase shrinkage. An AFS fracture test has been developed to indicate gas content of melt. ■ ■ ■

■ CARBON CONTROL IN ACID CUPOLA OPERATION/**Wally Levi,** Consultant, Radford, Va. . . . Carbon may be considered the most important element in gray iron because it has three times as much influence on physical properties in casting as either silicon or phosphorous. Once iron is tapped from the cupola it is relatively difficult to raise carbon content with a late addition. Some foundries are increasing carbon by continuous graphite injection. To make a reasonably close estimate of carbon at the spout the percentages of C, Si and P in the charge must be known. ■ ■ ■

■ GAS AND ITS CONTROL IN CAST ALUMINUM/**D. L. LaVelle,** American Smelting & Refining Co., South Plainfield, N. J. . . . Completely degassed aluminum may be desirable for highest quality castings but is excessively difficult to feed. A little bit of gas in commercial quality castings is a big help in dispersing gross

Committee members for the Conference are, front row, left to right: **H. A. Montgomery,** School of Metallurgical Eng., Purdue University; **J. C. Maggart,** Sibley Machine and Foundry Corp., South Bend, Ind., **C. T. Marek,** School of Metallurgical Eng., Purdue University; **H. B. Voorhees,** Manufacturers agent, Mishawaka; **D. F. Lunsford,** Perfect Circle Corp., Hagerstown Ind. Back row, left to right: **P. M. Semler,** Auto Specialties Mfg. Co., St. Joseph, Ind.; **K. E. Glancy,** Adult Education, Purdue University; **J. B. Essex,** Golden Foundry, Columbus, Ind.; **R. Schuhmann, Jr.,** and **W. M. Fitzsimmons,** International Harvester Co., Indianapolis.

F. L. RIDDELL

S. HODLER

D. L. LAVELLE

W. C. TRUCKENMILLER

R. F. THOMPSON

shrinkage. Best way of measuring gas content of melt is by solidifying a small liquid sample in an evacuated chamber. Sectioning the solid sample reveals the extent of gas content which has been magnified by influence of vacuum. Gas can be removed from molten aluminum by bubbling chlorine or nitrogen or by plunging hexachloroethane into the melt. In many respects the control of gas content is as important as the control of alloying elements. ■ ■ ■

■ METALLURGY AND FUTURE USES OF MALLEABLE IRON/ **Frank B. Rote,** Albion Malleable Iron Co., Albion, Mich. . . . (This paper was presented by W. C. Truckenmiller of Albion Malleable Iron Co.) High quality malleable iron demands castings which are annealed so no residual primary carbide remains and the graphite is fine, close packed and uniformly distributed. Annealing rate is controlled in part by the silicon which is maintained at highest practical level for short cycle heat treatment. Furnace atmosphere should be controlled so ferritic malleable is decarburized and pearlitic is not. The rate of growth for pearlitic malleable is now exceeding that of ferritic. This is particularly true in automotive industry where pearlitic castings are finding extensive use in automatic transmissions and power train components. ■ ■ ■

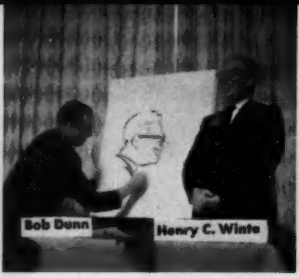
■ APPLICATIONS FOR CAST ALUMINUM INDUSTRY/**Robert F. Thompson,** Metallurgical Engineering Dept., GMC, Detroit . . . The use of aluminum in automobiles continues to grow. High silicon alloys continue to be evaluated and improved. The inherent coarse grain structure of the 16 per cent silicon alloy can be markedly refined by the addition of 0.01 per cent phosphorous. An aluminum engine can weigh up to 200 lb less than its cast iron counterpart. And with a lighter engine you can have lighter frame, tires and brakes. One serious drawback to aluminum cylinder blocks is the extensive heat treatment required. For a production rate of 10,000 units a day the heat treating furnaces alone would cover more than two acres. Die casting improvements are rapidly progressing. For instance, molybdenum and its alloys show considerable promise for cores and inserts. Precision cast dies are making steady gains. ■ ■ ■

■ SHELL CORES/**Robert Andrews,** Demmler Mfg. Co., Kewanee, Ill. . . . Internal contour of cores can be formed and wall thickness accurately controlled by using an internal mandrel. On split cores, tongue and groove joints are being used to create strong concealed joints. Collapsibility rate can be controlled by blending phenol-formaldehyde and urea-formaldehyde binders. Vibration applied to core box can often eliminate any need for ejection pins. Electric heaters will deliver a maximum of about 100 Btu per sq. in. of element surface area. Gas heaters can be made to deliver wider ranges of temperature gradients than electricity. Pitting of class B steels has been eliminated by adding 5 per cent calcium carbonate powder to a resin-coated zircon sand. Shell cores for magnesium should contain 0.5 per cent ammonia-borofluride powder. Where cored holes and cavities must be held to close dimensions, use a low melt point resin binder, cure at 350 F and extend cure time to three minutes. ■ ■ ■

■ HOW TO BUILD A SCRAP PILE /**William M. Grimes,** Gartland Foundry Co., Terre Haute, Ind.; **William A. Rodefeld,** Perfect Circle Corp., Hagerstown, Ind.; **Robert Hull,** Castings Service Co., La Porte, Ind. . . . **Grimes:** If foundrymen would spend as much time on improving green sand practices as they do on exploring new processes and techniques, they could solve many of their green sand problems. One way to hold down scrap is to keep molders responsible for all scrap. . . . **Rodefeld:** Scrap piles are built by human error. Four causes of scrap are: 1) falling for a magic potion, 2) trying to cure effect of scrap instead of finding the cause, 3) heaping too many irrelevant details on foreman, and 4) seeking "low-cost everything." . . . **Hull:** Watch five factors that contribute to scrap piles: 1) patterns—casting can be no better than pattern; 2) sand—try to develop a sand that suits all operations; 3) flasks—standardize as much as possible; 4) gating and risering—spend more time planning it; 5) human element—no operation is human-proof, so individual supervision is needed. ■ ■ ■

Speaker **R. S. L. Andrews** does some chalk-talking on shell core making.

This panel of **W. A. Rodefeld, W. M. Grimes** and **R. Hull** alerted the conference to scrap pile building practices.



Foundry Engineering Stressed at East Coast Regional

Inspired by the East Coast Regional Foundry Conference theme . . . Foundry Engineering for Quality Castings . . . 18 leading technologists of the metal-casting industry brought 260 foundrymen up to date on the latest practices.

The Conference, in New York City, Nov. 20 and 21, was broken into 3 half-day programs entitled: 1) Gating and Risering . . . 2) Mold Materials . . . and 3) Melting Procedures. Each half-day was in turn divided into three simultaneous sessions directed to the practices in 1) Steel, 2) Gray and Ductile Iron, and 3) Non-Ferrous Alloys.

On the nontechnical side of the program, cartoonist Bob Dunn entertained a large gathering at the official luncheon on Friday. And that evening foundrymen and their wives were treated to a cocktail party sponsored by over 100 vendors.

The Conference was sponsored by the Metropolitan, Chesepeake and Philadelphia Chapters of the American Foundrymen's Society. Metropolitan was the host Chapter. Conference chairman was James S. Vanick, International Nickel Co., New York; steel program chairman was Frank B. Herlihy, American Brake Shoe Co., Mahwah, N. J.; gray iron and ductile iron program chairman was Henry C. Winte, Florence Pipe Foundry & Machine Co.; and non-ferrous program chairman was William H. Baer, U. S. Army Engineers Research and Development Laboratory, Fort Belvoir, Va. Photographs for this story were provided by John R. Bing, Metropolitan Refractories Corp., Woodbridge, N.J.

GATING AND RISERING

• **EFFECT OF SOUNDNESS ON THE MECHANICAL PROPERTIES OF CAST HIGH STRENGTH STEEL** by **Hugo Larson**, American Brake Shoe Co., Mahwah, N. J. Good gating and risering will promote: 1) adequate soundness; 2) freedom from hot tears; 3) freedom from random sand and dirt defects; 4) freedom from blows and pinholes; and 5) uniformity of shape and dimensions from casting to casting. The importance of these benefits are magnified as you work with higher strength steels. X-ray studies revealed the potent influences of micro-shrinkage on ductility, toughness, tensile strength, bending strength and fatigue of high strength steels.

• **USE OF INSULATORS AND EXOTHERMIC COMPOUNDS IN RISERING STEEL CASTINGS** by **Harold F. Bishop**, Exomet, Inc., Conneaut, Ohio. Center line shrinkage arises from inadequate directional solidification and can be eliminated by: 1) placing risers closer together; 2) application of external chills; 3) the use of metal padding; and 4) the application of moldable exothermic padding. Wherever metal padding is successful it can usually be replaced with moldable exothermic padding of a thickness equal to 85 per cent of the metal padding. Exothermic riser sleeves are most helpful on small risers; but riser topping compounds are needed most on large risers.

■ **SOLIDIFICATION AND RISERING OF GRAY IRON** by **Clyde M. Adams**, Massachusetts Institute of Technology, Cambridge, Mass. Rice hulls have proven a good material for insulating tops of risers. Mold wall movement should be avoided because a little bit of it adds up to a lot of feed metal requirements. Evolution of graphite develops internal pressures sufficient to buckle mold walls.

■ **ECONOMICAL FOUNDING OF DUCTILE IRON** by **C. William Gilchrist**, The Cooper-Bessemer Corp., Mt. Vernon, Ohio. Cooper-Bessemer has realized substantial savings by producing ductile iron castings without risers. Process is made possible by: 1) adjusting metal composition for optimum graphite distribution to minimize metal shrinkage; 2) using molds of maximum rigidity rammed firmly in suitable sand within strong flasks; and 3) pouring rapidly through gates attached to thin sections.

▶ **GATING AND RISERING OF BRONZE CASTINGS** by **N. A. Birch**, National Bearing Div., American Brake Shoe Co., St. Louis. Establish as steep a temperature gradient as possible from casting to riser by using chills on casting and insulation on risers. To calculate rate of metal flow through gates use figure of 12 lb per sq in. per second. Trap slag and dirt in gating system with ratio of ingate: runner: downsprue areas of 1:2:1 plus.

▶ **RECENT DEVELOPMENTS IN MAGNESIUM FOUNDRY PRACTICE** by **J. G. House**, The Dow Metal Products Co., Midland, Mich. Magnesium is proving its versatility in applications ranging from extremely small precision investment castings to large, intricate thin-walled structures. Three different foundries have demonstrated their capabilities to product a 1450-lb casting for a guided missle ground-control system. CO_2 process cores have not been entirely satisfactory because of: 1) poor collapsibility; 2) high gas evolution; and 3) poor surface finish. Shell cores have worked well for magnesium—cross-sectional areas.

MOLD MATERIALS

• **REQUIREMENTS FOR STEEL MOLDING SANDS** by **E. C. Troy**, Pennsylvania Electric Steel Castings Co., Hamburg, Pa. Green sand molds were not freely used for steel casting until about 1930. Pinhole porosity in steel castings was blamed on mold moisture. Work at Battelle Memorial Institute in 1938 demonstrated the value of adding aluminum to steel as a pinhole preventative. This opened the door to rapid progress in casting all sized castings in green sand.

• **MOLDABILITY OF STEEL SANDS** by **George Watson**, American Brake Shoe Co., Mahwah, N. J.

Sources of oxygen need to be removed from the mold to avoid the fayalite reaction. With 4 per cent moisture green sand molds, samples of mold cavity gas taken as the metal rises in the mold show 50 per cent hydrogen. With dry sand molds hydrogen was 17 per cent. Water vapor must be kept as low as possible because its oxygen forms iron oxide and eventually iron silicate. The hydrogen is absorbed in the metal. For this reason waterless binders will be a beneficial development. Spalls, buckles and scabs form in a critical temperature range. The faster the sand passes through this range the less the chance of developing these defects.

■ **GRAY IRON MOLDING SAND** by **Victor Rowell**, Archer-Daniels-Midland Co., Cleveland. The most important advantages of naturally bonded molding sands are: 1) broad moisture tolerance with good resistance to drying; 2) mulling equipment is simpler; and 3) easier control. Synthetic molding sands have: 1) good uniformity and reproducibility of results and 2) minimum mold wall movement because of hard ramming possible with these high strength, low moisture sands. Even at mold hardnesses of 92 and green compressive strengths of 40 psi, scabs and buckles are unknown.

■ **VEINING AND PENETRATION** by **George DiSylvestro,** American Colloid Co., Skokie, Ill. The following factors promote or affect veining in castings: 1) increased gas evolution; 2) variations in raw materials; 3) coarser sand; 4) insufficient venting; 5) insufficient baking; and 6) silica flour additions. Veining may be reduced by using finer sands, iron oxide, bentonite, fire clay and core binders with a low gas content and rate of evolution.

▶ **FUNDAMENTALS OF THE CO_2 MOLDING PROCESS** by **E. A. Lange,** U. S. Naval Research Laboratory, Washington, D. C. For good dispersion of the sticky sodium silicate binders use a minimum of fines in the sand, small water and liquid sugar additions and minimum mixing time. A 10 per cent increase in green strength can be achieved by adding 1 per cent western bentonite and 1 per cent water. About 50 per cent of the sodium silicate solution is water which requires high permeability sands.

▶ **QUALITY CONTROL AND NON-DESTRUCTIVE TESTING OF NON-FERROUS CASTINGS** by **J. W. Clarke,** General Electric Co., Erie, Pa. Quality raw materials are an absolute must for quality castings. It is vendor's responsibility to maintain uniform product quality from day to day and from year to year. Melting stock is carefully cleaned even to the point of shot blasting before furnace charging. Alloys are synthesized by adding each element to the melt rather than buying custom ingot. Before pouring, aluminum alloy samples are solidified in vacuum to evaluate gas content.

MELTING PROCEDURES

• **CARBON ADDITIVES IN STEEL MELTING** by **Stanley A. Gilbert,** Petrocarb, Inc., New York. Carbon can be added to steel in the form of graphite electrode turnings, natural graphite, pitch cope, calcined petroleum coke, charcoal briquettes, anthracite coal and by-product coke. A new material called "gas coke" gives higher carbon recovery and lower sulphur pick up when added to steel.

• **RECENT ADVANCES IN STEEL MELTING PRACTICES** by **John Zotos,** Watertown Arsenal, Watertown, Mass. Recent advances in the basic-electric and basic-induction, atmospheric and vacuum steelmaking practices at the Watertown Arsenal's Rodman Laboratory have: 1) clarified the necessity of minimizing phosphorous and sulphur contents in cast low alloy steels to maximize ductility and toughness at low, medium and high strength levels; and 2) have shown that the ductility and toughness of these cast steels can be further improved through the use of vacuum melting and castings techniques.

■ **CUPOLA OPERATION WITH A BASIC LINING** by **W. W. Kerlin,** Meehanite Metal Corp., New Rochelle, N. Y. Basic lining and patching cost more than acid material but you can more than save it back by using cheaper charge materials. Basic lining may last as long as five years. Because basic magnesite has high expansion it's advisable to put cardboard between each brick to form expansion joints. Basic slag is so fluid it will run through 14 in. of slag hole without freezing.

■ **PRODUCTION OF DUCTILE IRON** by **Ralph A. Clark,** Union Carbide Metals Co., Cleveland. Cupola slag has ability to hold sulphur in proportion to its basicity. Basicity is equal to ratio of % CaO + % MgO: % SiO_2 + % Al_2O_3. If slag is natural, this ratio is equal to "1" and basic if greater. The higher the slag basicity the more sulphur it can hold and consequently remove from the iron. Basic cupola slag runs about 1.6 to 2 and has good desulphurizing power.

▶ **DEVELOPMENTS IN ALUMINUM ALLOYS AND CASTING PRACTICES** by **E. V. Blackmun,** Aluminum Co. of America, Pittsburgh, Pa. New aluminum casting alloys now available are: A140 and X250 for sand casting; C355 and A356 for permanent mold casting; and 364 and X385 for die casting. Foundries are also producing some satisfactory alloys by melting Al-Si-Cu and Al-Si alloy pig and then adding small amounts of Mg. The vacuum density test provides close control over the effect of melting, pouring and gating practices on the extent of porosity in castings. In the permanent mold process, special casting techniques result in high strength parts for aircraft, impellers and missiles.

▶ **BRASS AND BRONZE MELTING** by **Ray Cochran,** R. Lavin & Sons, Inc., Chicago. High-speed melting in reverberatory furnaces is gaining fast in popularity. Within ten minutes you can melt and raise to 2100 F a 350-lb batch of red brass. Never drop solid cold melting stock into a half melted bath because this practice introduces large quantities of undesirable hydrogen into the molten metal. Good atmosphere control in the furnace can eliminate need for fluxes and covers on the melt.

ANNOUNCING . . . .

1960 TRAINING COURSES SPONSORED BY AFS TRAINING & RESEARCH INSTITUTE

JANUARY-FEBRUARY

Subject and Description	*Dates*	*Course Length (Days)*	*Where Given*	*Course Fee*
Cupola Melting of Iron Instructional course for cupola operators, supervisors, metallurgists and foremen. Basic principles for efficient cupola operation are studied with emphasis on cost reduction. Raw materials, charging procedures, cupola design, combustion control, metallurgy of cast iron, maintenance, new developments and equipment, water-cooled, hot and cold blast operation discussions are also included. COURSE NO. 1	Jan. 11-15	5	Chicago	$90
Gating and Risering of Castings Instruction course covering theory and practice on the various problems relating to gating and risering of ferrous and non-ferrous alloys. Metal flow, solidification phenomena, heat transfer, shrinkage, hot tears, ferro-static pressure, gate and riser design, mold wall movement and surface tension are some of the facets considered. Calculation of riser size, pouring times and the placement and feeding distance of risers are important discussion topics. Intended for foremen, technicians, foundry engineers, supervisors, industrial engineers, and production and quality control personnel. COURSE NO. 2	Feb. 3-5	3	Chicago	$60
Metallurgy of Ferrous Alloys Intensive instruction on the basic metallurgy of ferrous alloys. Metal compositions, alloys, physical and mechanical properties. Metallographic examples are shown with the interpretation of microstructures. Valuable assistance in the understanding of basic structures, and the effects of heat treatment and control variables on mechanical properties. For melters, designers, metallurgists, engineers, researchers, supervisors and management. COURSE NO. 3	Feb. 22-24	5	Chicago	$60

Remainder of Courses to be Presented in AFS-T&RI 1960 Training Program

Melting and Heat Treatment of Malleable Iron $60
Course No. 4 — March 7-9 — Chicago

Casting Design and Stress Analysis $60
Course No. 5 — March 28-30 — Chicago

Shell Molds and Cores $60
Course No. 6 — April 11-13 — Chicago

Production of Ductile Iron $60
Course No. 7 — June-27-29 — Chicago

Blue Print Reading, Estimating $60
Course No. 8 — July 11-13 — Chicago

Welding and Brazing of Castings $60
Course No. 9 — Aug. 17-19 — Chicago

Core Practices $90
Course No. 10 — Aug. 29-Sept. 2 — Chicago

Foundry Refractories $60
Course No. 11 — Sept. 12-14 — Chicago

Economical Purchasing of Foundry Materials $60
Course No. 12 — Sept. 26-28 — Chicago

Sand Testing $150
Course No. 13 — Oct. 10-14 — Detroit

Foundry Plant Layout $60
Course No. 14 — Oct. 24-26 — Chicago

Metallurgy of Light and Copper-Base Alloys $60
Course No. 15 — Nov. 7-9 — Chicago

Sand Control & Technology $60
Course No. 16 — Dec. 5-7 — Detroit

REGISTRATION NOW OPEN. Make reservations for all 1960 AFS-T&RI training courses by course numbers and dates given. Registrations accepted in order as received.

Castings Congress Papers Bring Latest in Foundry Investigations to Entire Industry

■ Looking for a simple, understandable cost system? At the 1960 AFS Castings Congress, K. T. Rinderle, Farrell Cheek Steel Co., Sandusky, Ohio, will tell you how to set-up on-the-spot graphs to keep production expenses on target.

Because graphs are pictorial, a foreman can tell at a glance whether or not his foundry operations are under control. The system stresses simplicity, participation of the foreman in planning and the setting-up of cost centers.

Or perhaps you will be attending the 64th Castings Congress to learn more about gray iron. Want the latest information on riser feeding distance? Then don't miss the AFS Gray Iron Division progress report which reveals that the feeding distance is unlimited for adequate risers on simple, uniform shapes when casting unalloyed hypoeutectic gray iron in rigid molds.

The problems, how the investigation was conducted and further conclusions are in the report authored by J. F. Wallace, G. K. Turnbull and H. D. Marchant of Case Institute of Technology.

These important advances in metalcasting technology are just the beginning of a long parade of valuable developments to be announced in over 100 papers scheduled for presentation at the AFS Castings Congress May 9-13 at Philadelphia. Each of the AFS Technical Divisions as well as many General Interest Committees will sponsor sessions bringing the latest investigations to the attention of foundry management, technicians and research personnel.

G. K. Turnbull and H. D. Marchant are graduate assistants and J. F. Wallace is Assoc. Prof. Case Institute of Technology. Members of Gray Iron Division Research Committee are J. S. Vanick, Chairman, R. W. Clark, W. W. Edens, C. W. Gilchrist, R. Gregg, O. Meriwether, G. P. Phillips, J. E. Rehder, C. F. Walton.

Among other papers approved by the various Program and Papers Committees are Sand Inclusions in Large Magnesium Alloy Castings, Corrosion Resistance in Two Hot Work Die Steel, The Apparent Conductivity of Molding Sands at Elevated Temperatures, Job Analysis, Asset or Liability?, Parashrinkage Phenonema—Veining, Metal Penetration, Scabbing, Hot Tearing.

Each day the program will be started by an authors' breakfast. Authors and chairmen of the day's sessions will meet to cover final details to ensure smooth operation meetings.

In addition to the technical papers, the Castings Congress program will include six shop courses, two by the Gray Iron Division, two by the Malleable Iron Division and one each by the Sand Division and the Ductile Iron Division. A non-ferrous symposium will be presented and the Heat Transfer Committee and Fundamental Papers Committee will jointly sponsor a solidification symposium.

Luncheons will be held by the following divisions: Light Metal, Malleable, Brass & Bronze, Die Casting & Permanent Mold, Steel, Ductile and Gray Iron. The Management Committee will also hold a luncheon and Sand Division its annual dinner.

TENTATIVE SCHEDULE OF TECHNICAL SESSIONS

64th AFS CASTINGS CONGRESS & FOUNDRY EXPOSITION — May 9-13

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
7:30 am	Authors Breakfast	Authors Breakfast	Authors Breakfast	Authors Breakfast	Authors Breakfast
9:30 to 11:30 am	Light Metals Malleable Pattern Brass & Bronze	Brass & Bronze Pattern Malleable SH&AP T&RI Trustees	Annual Business Meeting & Hoyt Lecture	Steel Ductile Iron Fundamental Papers Die Casting & Perm. Mold	Sand Heat Transfer Ductile Iron Fundamental Papers
12:00 Noon	Light Met. Luncheon Malleable Luncheon	Brass & Bronze Lunch. Pattern Luncheon Board of Directors Luncheon & Meeting	Management Lunch. Die Casting & Perm. Mold R. T. Luncheon	Steel Luncheon Ductile & G. I. Lunch Past Presidents Lunch	
2:00 to 4:00 pm	Pattern Non-Ferrous Symposium (2:30-5:30 pm)	Light Metals Education Ind. Engrg. & Cost Gray Iron	Steel Die Casting & Perm. Mold Gray Iron Plant & Plant Equipment	Heat Transfer & Fund. Papers Joint Solidification Symposium Ductile Iron	
4:00 to 5:30 pm	Sand	Sand Light Metals Gray Iron Malleable	Ind. Engrg. & Cost Die Casting & Perm. Mold Sand Steel	Steel Gray Iron Sand	
6:00 pm		Canadian Dinner Sand Dinner	Annual Banquet	Alumni Dinner	
8:00 to 10:00 pm	Sand Shop Courses Mall. Shop Courses	Mall. Shop Course Gray Iron Shop Course		Gray Iron Shop Course Ductile Iron Shop Course	

Name Toth as Chairman of AFS Education Division

■ Jess Toth, Harry W. Dietert Co., Detroit, has been appointed Chairman of the AFS Education Division by society President Charles E. Nelson, replacing Prof. R. W. Schroeder, University of Illinois, Chicago, who resigned recently due to health necessities. Also appointed is Prof. James L. Leach, Dept. of Mechanical Engineering, University of Illinois, Urbana, Ill., as Vice-Chairman of the Division, in view of the inability of G. E. Garvey to succeed Schroeder.

The Education Division's activities are being reorganized to concentrate on several major areas including public relations, technical education and student activities.

Chairman Toth has announced the following appointments of committee chairmen for the two-year period 1959-60:

- Executive Committee–Chairman, Jess Toth.
- Program & Papers Committee–Chairman, B. L. Bevis, Caterpillar Tractor Co., Peoria, Ill.
- Apprentice Contest Committee–Chairman, G. E. Garvey, Garvey Pattern & Mfg. Co., South Bend, Ind.
- Foundry Instructors Seminar Committee–Chairman, D. S. Eppelsheimer, University of Missouri School of Mines & Metallurgy, Rolla, Mo.
- Publications Committee–Chairman, W. P. Winter, Pennsylvania State University, University Park, Pa.
- Students to Convention Committee –Chairman, E. G. Gentry, Penola Oil Co., Detroit.
- AFS Training & Research Institute Course Advisory Committee–Chairman, J. L. Leach.

J. Toth

J. L. Leach

Toth and Leach have both been active in foundry educational circles for a number of years. Toth is a past chairman of the Society's Detroit Chapter and the Chapter's Educational Committee. Leach has been Industrial Advisor to the highly successful Student Chapter of AFS at the University of Illinois since the Chapter was organized in 1952. Ralph E. Betterley, AFS Educational Director, was named Secretary of the Division.

Chairman Toth has appointed B. L. Bevis, Caterpillar Tractor Co., Peoria, Ill., and past Chairman of the Education Division, as the Division's Program Chairman for organization of the educational program at the 1960 Philadelphia convention.

At a special meeting of officers held October 13, a new film "Cast Metals and You" was previewed and approved for final production. The film now has been made available to educational institutions, civic groups, AFS Chapters and foundry organizations and already has proved exceptionally popular in telling the story of the foundry industry's importance in modern civilization. Another film, "The World of Cast Metals," now is being developed by the division.

Sand Committees Continue Research

■ Investigation into the problem of veining is being continued by the Sand Division's committee on the Physical Properties of Iron Molding Sands at Elevated Temperatures.

Research to date has not resulted in an acceptable test for the detection of veining tendency in sands. A steering committee has been appointed to check facilities for further work. Members are: C. L. Bowman, J. C. Dixon, J. A. Gitzen, E. N. Reusser, V. M. Rowell, and L. E. Taylor. The committee is also working on its section of the revision of the Sand Testing Handbook.

Pin hole porosity is being investigated by the Materials Used in Malleable Foundries Committee. Its plan will be based on a statistical analysis of replies by malleable foundries to questionnaires mailed by the AFS Central Office.

Testing procedures for silicate bonded sands and oil-oxygen binders have been approved by the Sand Division Core Test Committee. The proposed tests with minor revisions and additions have been submitted to the Sand Testing Handbook Committee for inclusion in the revised Sand Testing Handbook.

J. R. Cardwell
Chairman

C. E. Seman
Co-Chairman

AFS Southeastern Regional Meeting Set for Feb. 18-19

■ Technical sessions supplemented by plant visitations comprise the program for the 28th Southeastern Regional Foundry Conference to be held Feb. 18-19 at the Thomas Jefferson Hotel, Birmingham, Ala.

The conference is sponsored by the AFS Birmingham, Tennessee Chapters and the University of Alabama Student Chapter. Birmingham Chapter Chairman J. R. Cardwell, Stockham Valves & Fittings, Inc., Birmingham, Ala., is conference chairman with Tennessee Chapter Chairman C. E. Seman, Crane Co., Chattanooga, Tenn., as co-chairman. Ernest Finch, American Cast Iron Pipe Co., and Vice-Chairman of the Birmingham Chapter is conference program chairman.

The tentative program.

THURSDAY, FEB. 18

9:00 am Registration.
10:00 am Clyde A. Sanders, American Colloid Co., Skokie, Ill. Subject to be announced.
11:00 am AFS Secretary Ashley B. Sinnett, AFS Headquarters, Des Plaines, Ill.
12:30 pm Annual Luncheon.
2:00 pm *Charging Materials for Cupola Melting*, R. A. Clark, Union Carbide Metals Co., Div. Union Carbide Corp., Cleveland.
3:00 pm *Ductile Iron Production and Control*, Harvey E. Henderson, Lynchburg Foundry Co., Lynchburg, Va.
4:00 pm *Epoxy Resin Patterns*, M. K. Young, U.S. Gypsum Co., Chicago.
4:00 pm *Modern Foundry Refractories*, Ironton Firebrick Co., Ironton, Ohio.
6:30 pm Ladies Reception.

FRIDAY, FEB. 19

9:00 am Plant Visitation.
1:30 pm *Dielectric Core Baking*, speaker to be announced.
2:30 pm *Shell Molding*, Carl Schopp, Link-Belt Co., Indianapolis.
3:30 pm *Air Pollution*, speaker to be announced.
3:30 pm *Steel Casting Techniques*, speaker to be announced.
7:00 pm Annual Banquet.

Wisconsin Regional Features Simultaneous Sessions

■ Gray iron, steel, malleable and pattern sectional meetings will be held daily at the Wisconsin Regional Foundry Conference to be held Feb. 11-12 at the Hotel Schroeder, Milwaukee.

The conference is sponsored by the AFS Wisconsin Chapter in cooperation with the University of Wisconsin. Bradley Booth, Carpenter Bros., Inc., Milwaukee, is general conference chairman with Prof. P. C. Rosenthal, University of Wisconsin is co-chairman.

Eric M. Sobota, Wisconsin Electric Power Co., Milwaukee, is program chairman for general meetings and V. A. Guebhard, Jr., International Harvester Co., is program chairman for sectional meetings.

The program:

THURSDAY, FEB. 11

(Morning Sessions)

"Industry–College Cooperation," Dean Kurt F. Wendt, University of Wisconsin.

"Opportunities and Problems for AFS," Norman J. Dunbeck, AFS Vice-President, International Minerals & Chemical Corp.

"Recent Developments in the European Foundry Industry," John Varga, Battelle Memorial Institute.

"High Pressure Living," the Rev. T. Perry Jones, Sheboygan, Wis.

1st Afternoon Session

GRAY IRON—"High Strength Molding Sands for the Jobbing Shop," Victor M. Rowell, Federal Foundry Supply Div., Archer-Daniels-Midland Co.

STEEL—"Steel Melting," speaker to be announced.

MALLEABLE—"Shell Core Sand," Frank Less, Durez Plastics Div., Hooker Chemical Corp.

NON-FERROUS—"Problems of Aluminum Permanent Molding," Merlin Rostad, Rostad Aluminum Co., Edward Troy, Est Co., William Eckert, Metamold Corp.

PATTERN—"New Applications in Plastic Patternmaking," William Weaver, Modern Pattern & Plastics Co.

(2d Afternoon Session)

GRAY IRON—"Heat Treatment of Gray Iron and Ductile Iron," P. H. Dirom, Jr., Lynchburg Foundry Co.

STEEL—"Natural Gas Cutting," Glenn Hibbard, Milwaukee Gas Light Co.

MALLEABLE—"Molding Sand Clay Content," Joseph Schumacher, Hill & Griffith Co.

NON-FERROUS—"Aluminum Risering, Feeding, Degassing and Grain Refinement," Michael Bock, Exomet Corp.

PATTERN—"The Hows and Whys of Alloys for Patterns," O. J. Seeds, Cerro de Pasco Sales Corp.

BANQUET SPEAKER—"Iron and Steel Industrial Labor Contracts," Harold J. Ruttenberg.

FRIDAY, FEB. 12

(Morning Sessions)

GRAY IRON—"Quality Control in the Manufacturing of Gray Iron and Ductile Iron Castings," Tom Curry, Lynchburg Foundry Co.

STEEL—"Dow 230 Process," representative of Dow Chemical Co.

MALLEABLE—"Introduction and Administration of Standards," Robert Wills, Stevenson, Jordenson and Harrison Co.

NON-FERROUS—"CO_2 Practice," W. R. Oakley, Delhi Foundry Sand Co., Cincinnati.

PATTERN—"Electroforming for Pattern Construction & Repair," Phil Ritzenthaler, Plating Engineering Co.

LUNCHEON SPEAKER—"Industrial Psychology," Dr. Paul J. Mundie.

(Afternoon Sessions)

GRAY IRON—"The Gas-Fired Cupola," Carl R. Loper, Jr., University of Wisconsin.

STEEL—"Gating and Risering," R. A. Flinn, University of Michigan.

MALLEABLE—"Shell Technique," Hans Jacobs, Lehigh Foundry Co., Div. Lehigh, Inc.

NON-FERROUS—"Copper-Base Foundry Problems," R. A. Colton, Federated Metals Div., American Smelting & Refining Co.

PATTERN—"Patterns by the Shaw Process," Richard Christenson, Cast Masters.

AFS-T&RI Course in Sand Control Uses Specific Foundry Problems for Study

■ Solutions to foundry sand problems were advanced at the AFS-T&RI *Sand Control & Technology Course* Nov. 30-Dec. 4. in Chicago.

Prior to the study of individual cases, which were brought to the course by students, sand experts in the preceeding four days had detailed such subjects as basic concepts, particle packing, metal penetration, testing and tempering, mold wall movement, fracture and atmosphere, casting finish, additives, mechanically molded sand properties, sand reclamation and casting losses.

Instructors also aided in diagnosing the individual cases. Students in submitting their problems, included data on metal poured, sand specifications and characteristics, coremaking methods, core baking or curing cycle, melting equipment, pouring temperature, casting weight and a description of the specific problem.

These factors plus an outline of the specific problem in each area and a sketch of the casting were circulated among students for possible solutions. This approach has been used successfully in the past in the T&RI courses and T&RI Training Supervisor R. E. Bettlerley has stimulated considerable class participation.

Instructors were Jack Caine, consultant, Cincinnati; H. W. Dietert and V. M. Rowell, Harry W. Dietert Co., Detroit; T. W. Seaton, American Silica Sand Co., Ottawa, Ill.; T. E. Barlow, Eastern Clay Products Co., International Minerals & Chemical Co., Skokie, Ill.; C. T. Jones, National Engineering Co., Chicago.

Ductile Iron Research Committee, left to right: AFS Technical Director **S. C. Massari, H. G. Haines,** Woodruff & Edwards, Inc., Elgin, Ill.; **A. W. Anderson,** International Harvester Co., Chicago; **W. M. Spear,** Worthington Corp., Harrison, N.J.; **A. J. Fruchtl,** James B. Clow & Sons, Inc., Coshocton, Ohio; **A. H. Rauch,** Deere & Co., Moline, Ill.; **H. W. Ruf,** Grede Foundries, Inc., Milwaukee.

Key to Success:

CUSTOMER SATISFACTION

By W. A. Szott
Central Foundry Div., GMC
Danville, Ill.

■ Today the castings industry is faced with a situation similar to an old cliche which states that . . . *"the significance of man is that he is insignificant . . . and he realizes it."*

This quotation applies to our situation in that we . . . as members of the foundry industry . . . must recognize that gone are the days of 1/4-in. finish stock and the practice of adding sufficient amounts of stock to compensate for uncontrolled foundry variables.

Our industry is in the midst of an era of stress analysis, radiography, precision casting and a host of similar technological advances. And the fact is . . . we are not taking these measures purely to increase our profits; we are doing so just to maintain them.

During the past few years, our customers have found it necessary to develop new processes and techniques in order to maintain a competitive position in their respective markets. In so doing, they have turned to automation which by its very nature results in high volume production at a reduced cost.

As an example of how the advent of this automatic or semi-automatic equipment has affected the foundry, it is now necessary to maintain a closer control on hardness ranges in the interests of casting machinability. Here, the customer is concerned

AFS Study Compares Broad and Narrow Sand Distributions

by Victor Rowell
Archer Daniels Midland Co.
Cleveland

Within the last ten years, there has been a trend toward the use of finer sands for all cast metals to promote better finish. In addition, attention has been given to sands possessing stability that will enable production of accurate castings free from surface blemishes.

The old practice of coarse sand and silica flour was partly, at least, intended to promote high density so that the metal would not penetrate the mold surface.

Investigations conducted by members of the AFS Basic Concepts Committee have shown that this approach is fundamentally correct. However, it has been established that with particles of uniform size in each instance the finer the grain the less maximum density is possible.

In some local areas, there has been a certain amount of agitation against the use of silica flour despite the fact that this has been, and is, a useful material for steel sands. In comparing six simple sand mixtures certain trends stand out in a rather interesting manner.

From a standpoint of rammed density, assuming the application of constant ramming energy, the density is higher with the broad distribution sand than it is with narrow distribution. It is rather interesting to note that the density of the broad distribution sand with only 5 per cent bentonite added is higher than the density achieved with the narrow distribution sand plus 10 per cent silica flour when bonded with 5 per cent bentonite. In all cases the density was higher with the broad distribution sand. Cereal, of course, tends to reduce density slightly due to impairment of flowability.

As the density is increased the permeability is decreased. These two factors are generally inversely proportional. The one exception is that the narrow distribution sand, with cereal, does not quite fit the general pattern, showing a little higher permeability than might be expected from the density. Green compressive strengths, in all cases, were appreciably higher with the broad grain distribution sand.

Deformation, of course, is dependent, as are all other properties, on moisture level but at a normal workable level became somewhat higher with the cereal mix. Grain distribution has little, if any, effect on green deformation.

In all cases the sand with the broader grain distribution produces considerably higher green tensile strength than the narrow grain distribution. The green tensile strength is highest on the sand mixes containing only 5 per cent bentonite.

Dry compressive strength is enhanced to some degree by the addition of cereal although highest values were reached with silica flour.

The hollow confined expansion at 1500 F was approximately the same in sands of either type of distribution. The addition of silica flour made practically no difference. Cereal, however, did reduce expansion noticeably.

Hot strengths at 2000 and 2500 F were higher in all cases with the broad distribution sand. Highest levels were reached with silica flour. The lowest values were in the mix containing cereal.

The highest order of hot deformation or plasticity at this temperature was achieved with nothing but sand and bentonite with practically no difference between narrow or broad distribution. The most brittle sands were those containing cereal, probably the carbon present tended to inhibit glazing.

The lowest restraining load figure was obtained with the cereal mix. In this particular series, on the mixtures without cereal, restraining load worked out to very similar levels whether or not silica flour was employed.

The sands with the broad distribution exhibited noticeably better stability than did the sands with narrow distribution. The best in this series appeared to be those containing cereal and the worst were those containing silica flour.

The broad grain distribution sand seems to be highest in density, green compressive strength, green tensile strength, dry compressive strength, hot strength and glazing ability. This broad distribution was lowest in permeability and rate of expansion as well as definitely superior in spalling resistance. The narrow grain distribution with the silica flour had the highest permeability, lowest density, dry and hot strengths and fell between the other two regarding the other properties.

The narrow distribution sand plus silica flour was lowest in green compressive and tensile strengths, poorest in glazing characteristics and exhibited the worst appearance on exposure to thermal shock. ■ ■ ■

This article contains highlights abstracted from a paper presented at the 1959 Wisconsin Regional Foundry Conference.

from the standpoint of tool cost and the volume of machining that will be required. Also, the automatic fixtures and transfer equipment utilized in his operation require castings with closer tolerances and of more uniform size.

Because of these factors, our customer specifications are now more restrictive than ever. The increasingly rigid lines drawn on quality and tolerances are but a polite way of our customers saying, "Produce . . . or else."

There are a number of positive approaches that may be undertaken in assuring our customers that we are striving to meet their demands. Four of these include: 1) Statistical quality control; 2) Improved inspection methods and devices; 3) Customer follow-up; and 4) Co-operative engineering.

STATISTICAL QUALITY CONTROLS: This is a comparatively new concept of inspection adopted by many foundries in order to satisfy rigid customer requirements. It may be applied to intermediate phases of production as well as final inspection prior to product shipment.

By using statistics . . . and an examination of a relatively small sample of castings . . . it is possible to determine the quality level of an entire shipment faster and more accurately than in the past. Also, by adapting certain variations of quality control to production processes, it is possible to relate to the man on the line any number of procedural changes which will help prevent defects in the final product.

THE DEVELOPMENT OF NEW AND IMPROVED INSPECTION DEVICES: The magna-flux and magna-glo techniques have been used quite extensively in ferreting out surface cracks in castings. Ultra-sonic testing has fulfilled the need for a non-destructive method of checking the internal structure of a casting.

The cobalt-60 . . . or radiography unit . . . which operates on the same principle as the hospital x-ray machine, has provided another non-destructive means of revealing hidden casting defects which previously could not have been detected prior to machining operations.

CUSTOMER FOLLOW-UPS: A qualified foundry representative should make scheduled personal visits to our customer plants.

The primary objective of such a contact man is, of course, to provide effective communication between foundry production facilities and the recipients of our castings.

It is he who is in a position to pin down the causes of customer complaints and relay the information back to our plants—and it is he who can suggest possible foundry assistance in the areas of new development work high on the customer's priority list.

Once back in the plant, the contact man is able to solicit the assistance of any number of specialists in the fields of production, engineering or metallurgy who can concentrate immediately on the problem.

He frequently is in a position to recommend changes such as a redesigned gate or parting line based on his own product knowledge; however, when a particular problem arises at a customer plant, one of the aforementioned specialists quickly travels to the problem point and refers his recommendation back to the foundry.

On the basis of his observation of customer machining operations, the contact man often is able to recommend substantial cost-saving changes such as the elimination of specific operations performed at the point of production. Based on his findings, a foundry is able to compile meaningful performance records . . . often of significance to the entire industry.

Particularly noteworthy is the fact that he is able to gather information pertaining to customer processes and designs still in the planning stage . . . thus providing the foundry industry with a glance at future requirements. As in the game of bridge, 'one peek is worth two finesses.'

COOPERATIVE ENGINEERING: This basically is a new approach to an old problem . . . i.e. acquainting the customer with the capabilities of the castings industry, and assisting him with the practical design of his product in its relation to casting production.

Central Foundry Division recently initiated a program to do this very job . . . now known as a Castings Design Conference. Invited to such a meeting are technical representatives of our customer firms such as product engineers, metallurgists, methods men, etc. Our primary aim is to acquaint them with foundry terminology, modern molding methods, foundry tooling costs and basic casting procedures.

The conferees are taken on a tour of the host plant, allowing them to see in operation many of the developments described earlier in the conference. In doing this, we feel that a two-fold objective is accomplished . . . (1) that of bringing our customers up to date on the tremendous strides made recently in the castings industry, and (2) that of pointedly reminding their design engineers not to overlook any possible uses of cast parts.

We must continue to live and breathe quality, and realize that the road to an improved competitive position is paved with satisfied customers.

This article contains highlights abstracted from a paper presented at the 1958 Purdue Metal Castings Conference.

EXPERIMENTAL WORK ON MALLEABLE IRON

By L. C. MARSHALL, G. SOMMER *and* D. A. PEARSON
Link-Belt Co. Indianapolis

■ Experimental work is in progress to determine high temperature stress-rupture and creep properties of malleable iron. The ultimate objective of this work is the achievement of tentative use specifications for ferritic and pearlitic malleable irons requiring load carrying ability for prolonged intervals at elevated temperature. High and low carbon ferritic unalloyed materials have been tested at 800 F, 1000 F, and 1200 F for times up to 2300 hours. Pearlitic malleable iron produced by arrested first-stage graphitization following a small manganese ladle addition has been tested at 800 and 1000 F for times beyond 1000 hours. Careful metallographic studies of the failed test specimens have been completed.

The data obtained for ferritic material indicate a high level of rupture stress, equal or superior to ferritic cast materials for which data are available. The low carbon ferritic material indicates approximately 50 per cent increase in strength over the high carbon ferritic material at 800 F. But at 1000 F and 1200 F, the two materials show no significant difference in behavior. This exceptional behavior of low carbon ferritic malleable iron at 800 F cannot be explained from the data or from metallographic examination.

The strength at 1000 and 1200 F is adequate for many uses. All data exhibit a good linear fit to the log-log plot which indicates that no fundamental changes of structure or physical characteristics have taken place. The pearlitic malleable iron tested appears superior to other unalloyed cast pearlitic irons and equal or superior to most alloyed cast irons. The time-elongation curves portray the normal ductile behavior of both ferritic and pearlitic malleable for the times and temperatures investigated.

This article contains highlights abstracted from a paper presented at the 1959 Penn State Regional Foundry Conference.

chapter news

Northwestern Pennsylvania Chapter members made visit to Cooper-Bessemer plant. W. E. Eccles, foundry superintendent, second from left, discusses a core with visitors.

C. C. Sigerfoos, Michigan State University, spoke at the **Saginaw Valley Chapter** in October on his visit to Yugoslavia. Shown are Technical Chairman **F. J. Hodgson,** Eaton Mfg. Co.; speaker **Sigerfoos;** Chapter Chairman **Ormond Requadt,** Dow Chemical Co.; Vice-Chairman **G. R. Frye,** Eaton Mfg. Co.
—**John R. Fraker.**

Viewing exhibit at **Twin City** meeting are **C. G. Schelly,** DoAll Co.; **Norm Silver,** Continental Machine Co.; Chapter Chairman **Carter DeLaittre,** Minneapolis Electric Steel Co.; **Fred Quest,** Shakopee Foundry Co.; **Harry Blumenthal,** American Iron & Supply Co.; **Russ Lauderdale,** Northern Pump Co.

Ontario Chapter members in October heard L. B. Knight, Lester B. Knight & Associates, Chicago, speak on modernization in large and small foundries. Shown are: speaker **Knight; G. Fellows,** Ford Motor Co. of Canada, Windsor, Ont.; **A. Kavasi,** Auto Specialties Mfg. Co. (Canada) Ltd., Windsor, Ont.; **E. Rempel,** McCoy Foundry Co., Hamilton, Ont.

Chicago Chapter

Conducts Simultaneous Sessions

■ Simultaneous steel, non-ferrous, iron and pattern sessions were held at the Chicago November meeting.

C. G. Mickelson, American Steel Foundies, addressed steel foundrymen on "Short Time Heat Treatment," explaining that equipment and processes are now available which considerably reduce hold time. Savings in time are also possible through modification of existing equipment. Mickelson pointed out that other foundry operations have been speeded but that more attention should be given to heat treating operations.

J. R. Vogt

J. R. Vogt, Union Carbide Metals Co., Union Carbide Corp., spoke on "The Challenge of Aluminum to Iron," pointing out that considerable inroads in iron production have been made by aluminum, particularly in the automotive industry. Among the factors contributing to the trend are aluminum's lightness, high thermal conductivity, high strength to weight ratio, high fluidity and ease of casting.

A five-man panel commented on non-ferrous scrap castings submitted for discussion. Most castings were 85-5-5-5, manganese bronze and aluminum. Panelists were: Bill Foss, Apex Smelting Co.; Richard Ligocki, Hammond Brass Works; Joseph Mulvey, Crane Co.; and Jerry Curto and Pete Scarpelli, Curto-Lingonier Foundry Co.

Herbert Nelson, Arrow Pattern & Foundry Co., discussed plastics at the pattern session, stressing the advantages of laminated epoxy resin patterns and core boxes including excellent wearing and drawing qualities of silicon carbide faced pattern equipment, ease and low cost of duplication. He also outlined the proper way of constructing and reinforcing pattern equipment.

Lawrence Labuda, formerly at the University of Illinois branch at Navy Pier, Chicago, and now a junior in mechanical engineering, University of Illinois, Urbana, Ill., was awarded the chapter's Robert E. Kennedy scholarship award.

Foundry Educational Foundation scholarships were given to Donald A. Dudle, Richard Sanford, Thomas H. Sytko, Arthur R. Tomszak and Raymond Wakefield, all students at the University of Illinois, Chicago.

Chapters Sponsoring Educational Courses

■ Three AFS Chapters, Philadelphia and Northeastern Ohio and Ontario are sponsoring educational courses during the 1959-60 year.

The Philadelphia Chapter conducts weekly foundry courses at Murrell Dobbins Vocational-Technical School starting on Nov. 16 and extending until March 21. The curriculum includes lectures, shopwork and plant visitations.

Subjects and teachers are: *Foundry Sands,* Charles Mooney, Olney Foundry, Link-Belt Co.; *Core Sands and Binders,* Joseph Sabol, Olney Foundry; *Coremaking and Molding,* Al Spitz, Pennsylvania Foundry Supply Co., Howard Hunter and Warren Longnecker, Atlantic Steel Castings; *Non-Ferrous Processing,* Robert Schmidt and Roger Keeley, Ajax Metal Div., H. Kramer & Co.; *Steel Melting,* Ed Berry, Dodge Steel Co.; *Patterns and Pattern Equipment,* Ray Huntoon, Pressure Match Plate Co. and Robert Kruse, Kruse Pattern Work; *Gray Iron,* E. X. Enderlein, Enderlein Foundries and John Anspach, Meehanite Metal Corp.

Plant visitations, will be made at Northern Bronze Corp., Dodge Steel Co., Florence Pipe & Foundry and Philadelphia Coke Co.

The Ontario Chapter is conducting a 22-week foundry course at the Central Secondary School in Hamilton, Ont. Classes started Oct. 6. Subjects include sand, cupola operation, molding, metallurgy of ferrous and non-ferrous castings, gating and risering, cleaning, safety and coremaking. Central Secondary School has a small foundry.

The Northeastern Ohio Chapter will conduct a three-week course on *Profitable Foundry Management.* Speakers and their subjects are: Feb. 9, *Profitable Foundry Operations,* Harry Figgie, Jr., Booz-Allen & Hamilton; Feb. 16, *Profitable Foundry Marketing,* Richard Meloy, Gray Iron Founders' Society; Feb. 23, H. J. Weber, AFS Director of Safety, Hygiene & Air Pollution Control, *Profitable Foundry Environment.*

Patternmakers at the **Chicago Chapter** November meeting heard **Herbert Nelson,** standing, and technical chairman **Bob Swanson,** seated, both of Arrow Pattern & Foundry Co., discuss plastics.
—**George Disylvestro**

Lawrence Labuda, student at University of Illinois, Urbana, Ill., winner of the **Chicago Chapter's** Robert E. Kennedy Scholarship Award, is congratulated by **Dean F. W. Trezise,** University of Illinois, Navy Pier.

R. L. Gilmore, Superior Steel & Malleable Castings Co., Benton Harbor, Mich., addressing the Michigan Chapter on "Casting Design for Survival." A movie, castings and design illustrations supplemented the talk.
—**A. J. Stanczky**

Participants in Chicago Chapter's non-ferrous scrap panel were: **Richard Ligocki,** Hammond Brass Works; **Joseph A. Mulvey,** Crane Co.; **Bill Foss,** Apex Smelting Co., **Jerry Curto,** Curto-Ligonier Foundry Co. Panel analyzed castings brought by chapter members.
—**George DiSylvestro**

Eastern New York Chapter

Gypsum Pattern Material

■ How to use gypsum for pattern material was explained at the September

meeting by M. K. Young and Jim LaPlante, U. S. Gypsum Co. A film showed step-by-step procedures for use of epoxy resins.

—Leonard C. Johnson

C. C. Smith, General Metals, Vancouver, B.C., and former chapter chairman, won British Columbia golfing trophy. Director **C. I. Brett,** Metro Brass & Aluminum Foundry, Burnaby, B.C., on right, presents trophy.
—**N. D. Amundsen**

Rochester Chapter

New Equipment Developments

■ New developments in melting and charging equipment at Modern Equipment Co. include a sealed cupola, mechanical charger, a new approach to recuperative hot blast and emission cleaning and an externally water-cooled cupola. These developments were explained at the November meeting by H. W. Schwengel.

In charging the cupola the maximum rate is 40 tons hourly. The automatically loaded bucket on moving upward engages the bucket cover, a metal skirt contacts with the water in a water tank making a seal on the cupola. The bucket is dumped and gases can enter the bucket and also go along side the bucket but cannot escape the seal.

In closing the cupola is sealed from the atmosphere eliminating air infiltration and reducing the amount of air to be handled by ducts, combustion unit, cleaner and fan.

—Haerle Wesgate

Central Illinois Chapter

Getting Started in Industry

■ One hundred students from the University of Illinois accompanied by Prof. James Leach attended the November meeting devoted to students and the foundry industry.

Clyde L. Schwyhart, Caterpillar Tractor Co., Peoria, Ill., spoke on getting started in industry. He listed five rules for success in supervision: 1) let each person know how he is getting along, 2) give credit where credit is due, 3) tell people in advance of things that will affect them. 4) assign people work they can do, 5) treat each person as an individual. Schwyhart said that most people fail not because of a lack of technical knowledge but because of their failure to understand people. Other talks were given by Robert Newell, supervisor of Trade and Industrial Education, State of Illinois Board of Education Vocation; AFS Secretary A. B. Sinnett and former AFS President Frank W. Shipley, Caterpillar Tractor Co.

A. B. Sinnett

–C. H. Bavis.

Clyde L. Schwyhart, speaker at the Central Illinois November meeting flanked by technical chairman **George Steimle,** Caterpillar Tractor Co. and Chapter Chairman **John Kauzlarich,** Peoria Malleable Castings Co.

Twin City Chapter

Joint Meeting with A.S.M.

■ Twin City foundrymen and members of the American Society of Metals held a joint meeting Oct. 28. C. G. Schelly, DoAll Co., Des Plaines, Ill.

Schelly spoke on "The Story of the Cutting Edge," tracing the development during the past million years to the present industrial edges. He stated that the present steel age is just another step in development in knowledge and skills of the preceeding era. *–Matt Granlund*

Quality control application in the foundry was explained to **Pittsburgh** Chapter members in October by **Allen A. Evans,** International Harvester Co., Indianapolis, shown on left. **George Miklos,** Westinghouse Electric Corp., was the discussion leader. **—Walter Napp**

Cincinnati Chapter

Mold, Core Sand Additives

■ A review of sands and types of additives used in the past as well as at present was presented at the November meeting by J. A. Gitzen, Delta Oil Products Corp., Milwaukee. Following the talk a discussion was held. Chapter Chairman James D. Claffey, Nonferrous Castings Co., Dayton, Ohio, acted as the presiding officer and technical chairman. Approximately 100 foundrymen attended the meeting held at the Engineers Club.

Eastern Canada Chapter

Makes Plant Visitation

■ Chapter members in November visited the Joliette Steel Div. plant of Dominion Brake Shoe and heard a talk on foundry mechanization by H. M. Brownrigg who discussed methods for speeding casting operations. *–J. W. Cherrett*

George DiSylvestro, American Colloid Co., Skokie, Ill., left, addressed **Northwestern Pennsylvania** Chapter in October on "Veining and Penetration." Chapter President **Wm. Eccles,** Cooper-Bessemer Corp., Grove City, Pa., offers congratulations. **—Walter Napp**

Alloyed ductile irons were discussed at the November meeting of the **Southern California** Chapter by **L. S. Wilcoxon,** International Nickel Co. Shown are speaker Wilcoxon, Chapter Chairman **E. G. Gaskell,** Ace Foundry, Ltd.; technical chairman **C. F. Weisgerber,** Alloy Steel & Metals Co. **—K. F. Sheckler**

Ontario Chapter

Modernization of Foundries

■ Modernization of large and small foundries with many comparisons to European foundries was explained at the October meeting by Lester B. Knight, Lester B. Knight & Associates, Chicago. In Europe, much use is made of CO_2 process and shell molding and emphasis is placed on research. Individual plant research development departments are numerous and apprentice training school keep a flow of recruits coming to the industry. *–John T. Kay*

Panelists at **Central Michigan** shell core and mold discussion. **Bill Bopp** and **Al Doerr,** Midwest Foundry; **C. R. Baker,** Albion Malleable Iron Co., Albion; Chapter Chairman **Stephen Pasick,** Battle Creek Foundry Co. **—Jack Hoaglin, Melvin W. Devers.**

Washington Chapter

Alloy Ductile Iron Talk

■ An illustrated lecture on the various properties of plain and alloyed ductile and well as Ni-Resist ductile irons after various heat treatments was presented at the November meeting of the Washington Chapter by L. S. Wilcoxson, International Nickel Co.

About 90 per cent of the tonnage produced is from basic-lined cupolas. The base iron, which must be low in S, P. and Mn, allows the magnesium addition to act as an alloying agent instead of being tied-up with sulphur. Cerium helps overcome the effects of several other elements which are detrimental to the formation of ductile iron.

About 75 per cent of foundries use the transfer ladle method and 25 per cent use the plunging technique in the production of ductile iron, both methods are followed by a final inoculation treatment with ferro-silicon. Nickle addition (up to 5 per cent) to ductile iron increases strength, hardenability and ductility of ductile iron, also preventing carbide formation with any strength-building molybdenum additions.

Ductile Ni-Resist must contain from 0.08 per cent to 0.15 per cent residual magnesium in comparison to 0.04 per cent to 0.07 per cent residual in the case of regular ductile iron, necessitating up to twice the magnesium addition.

Ductile Ni-Resist has poor fluidity and needs a high pouring speed at a temperature of at least 2625-2700 F. The normal heat treatment applied to gray iron does not have a pronounced effect upon the properties of ductile Ni-Resist, temperatures above 1750 F being required to break down carbides.

—Hubert L. Rushfeldt

W. M. Ball, Jr., R. Lavin & Sons, Chicago, addressed St. Louis foundrymen on the effects of design on the making of a casting. On right is Chapter Chairman **R. E. Hard**, St. Louis Coke & Foundry Supply Co.

—W. E. Fecht

Greeters for **Pittsburgh Chapter** are **J. F. Herman**, Corn Products Co. and **L. W. Adams**, Pittsburgh Coke & Chemical Co.

—Walter Napp

Twin City Chapter

High-Purity Alloy Talk

■ High-strength aluminum casting alloys were discussed at the November meeting by A. B. DeRoss, Kaiser Aluminum & Chemical Sales, Chicago. High-purity alloys give exceptional high tensile and yield strengths and retain ductility after heat treating. Emphasis was placed on alloy 357, an aluminum-silicon-magnesium alloy developed for applications calling for high yield strength.

—Matt Granlund

Tri-State speaker **John Albanese**, Acme Resin Corp., and program chairman **Harry Ferlin**, Tulsa Pattern & Mfg. Co., Tulsa, Okla.

—Frank M. Scaggs

Central Michigan Chapter

Yugoslavian Foundry Report

■ Prof. C. C. Sigerfoos, Michigan State University, East Lansing, Mich., at the November meeting, related his experiences in Yugoslavia as a technical advisor for the International Cooperative Administration. Sigerfoos said one of the major problems was the lack of quality and uniformity of basic raw materials which was reflected in the finished product.

—Melvin Devers

Tri-State Chapter

Phenolic Resin Applications

■ A Japanese film on shell molding was shown at the November meeting by John Albanese, Acme Resin Corp., Chicago, in explaining phenolic resins and their application to sand. The film showed steel shot used to back up molds with the shot later reclaimed. Liquid resin was also used in the operation.

Albanese stated that round-grain sand uses less resin and makes a harder mold and hot-coated sands are superior to cold-coated sands due to better distribution of the resin.

—Frank M. Scaggs

Attending November meeting of **Tri-State Chapter** were **Jackson Dean**, Nelson Electric Mfg. Co., Tulsa; **Frank Newberry**, Oklahoma Steel Castings Co., Tulsa and former AFS National Director **Robert Trimble**, Bethlehem Steel Co., Tulsa, Okla.

Bargain Sam—the cut-rate man, president of the fictional Chee-P Mfg. Co., a panelist on shell cores and molds at the **Central Michigan** Chapter, looks at display by Midwest Foundry Co., Coldwater, Mich. Sam is plotting another price-cutting spree.

Relaxing after dinner at **Pittsburgh Chapter** are **Art Pander**, Homestead Valve Mfg. Co.; **Jack Parsons**, Peninsular Grinding Wheel Co.; **Marty Manion, Norm Greig** and **Clarence Stevenson**, all from Centre Foundry & Machine Co.

Correct use and latest developments of exothermics was discussed at the November meeting of the **Eastern Canada Chapter** by R. W. Ruddle of Foundry Services, Inc., Cleveland. Discussed were solidification and risering of castings, feeding aids, moldable exothermic compounds and green and dry strength of compounds. Left to right are: **E. R. Landry, Max Reading, Michael Notte,** speaker **Ruddle,** Chapter Chairman **A. H. Lewis, Norton Watson, James Cherrett, Leo Myrand, Alex Bain and Gerald Tracy.** —**James W. Cherrett**

Shown at November meeting of Ontario Chapter are **S. E. Robinson,** John Bertram & Sons; **W. B. Milholland, Jr.,** Holmes Foundry, Ltd.; **George Fellows,** Ford Motor Co. of Canada, Ltd.; **E. W. Chapman,** Cooper-Chapman, Ltd., who spoke on the shell molding process. —**Vincent H. Furlong**

Birmingham Chapter

Ductile Iron Practice

■ The importance of ductile iron as an engineering material was explained at the November meeting by David Matter, Ohio Ferro Alloys Corp., Canton, Ohio.

D. Matter

Various melting practices and methods of adding magnesium and inoculants were covered as well as relative costs when using various magnesium alloys and inoculants. Other topics were variations in physical properties of ductile iron due to chemical composition and heat treatment, history of the process, manufacturing procedures and applications. —*Edwin Phelps*

Northwestern Pennsylvania Chapter

Selling Castings Profitably

■ Five steps in selling more castings profitably were given to foundrymen at the November meeting by R. C. Meloy, Gray Iron Founders' Society. Meloy's five Ts were:

- Training of personnel to know your costs.
- Tools, such as brochures, pictures and samples.
- Time to sell the customer.
- Task—Employer should set up the program and check progress.
- Treatment of customer as to engineering services.

—*H. L. Buchanan*

Texas Chapter

Veining and Penetration

■ Eighty-three members and guests of the Texas Chatper and 17 members of the Texas A & M Student Chapter attended the Nov. 13 meeting in Marshall to hear George DiSylvestro, American Colloid Co., Skokie, Ill., discuss veining and penetration.

DiSylvestro reported on research work with core sand mixtures subjected to actual casting conditions. Using a symmetrical test casting design with varying materials and proportion and photographing the results, he was able to illustrate the effects of minor variation in the core mix.

Detroit Chapter

Foundry Cost Systems

■ A four-point system for cutting foundry costs was outlined at the November meeting by E. M. Hinze, E. T. Runge & Associates. Foundrymen attending the annual management night were told that these points were:

- Define goals.
- Be positive of yourself.
- Refuse negativety.
- Do things required now.

Each point was explained and how it applied to the foundry industry. Hinze also presented a plan to help foremen promote the acceptance of cost reduction. Specific examples of cost reduction programs were cited by Hinze.

Chapter Chairman Grant Whitehead, Dace Industries, Ltd., Windsor, Ont., presided at the meeting. —*J. R. Young*

Central N.Y. Forms New Elmira Section

■ A new section of the AFS Central New York Chapter has been formed in the Elmira, area to better serve a number of large foundries located at considerable distance from the Syracuse headquarters of the parent group. The new section will be known as the Southern Tier Section of Central New York and expects to hold four technical meetings a year on the third Friday of each month.

Chairman of the new section is I. Niles Kitchen, Ingersoll-Rand Co., Painted Post, N. Y. Vice Chairman is J. B. Stazinski, General Electric Co., Elmira, N. Y., and the section Secretary is J. T. Coggin, also of General Electric at Elmira. At a "kick-off" dinner meeting held November 20 at Elmira, W. D. Dunn, Oberdorfer Foundries, Inc., Syracuse, N. Y., and AFS Regional Vice-President, discussed the advantages of society membership and activities. Following his talk, the section officers were elected and a schedule of three further technical meetings announced as follows:

Jan. 15, Corning, N. Y.—sponsor Ingersoll-Rand Co.

Feb. 19, Elmira, N. Y.—sponsor Kennedy Valve & Mfg. Co.

March 19, Elmira, N. Y.—sponsor Chemung Foundry Corp.

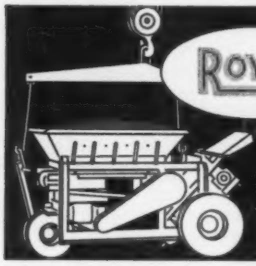
Several Chapters of the society have established sections in outlying areas so as to avoid excessive travel in the winter months and to bring national speakers on foundry topics closer to foundrymen in concentrated industrial areas. The Texas Chapter now has three such sections. The former Piedmont section of the Chesapeake Chapter has now become a bona fide Chapter in its own right. Officers of the Southern Tier section of Central New York are elected to serve for one-year terms but may be re-elected for three successive terms of one year each. Chairman Kitchen is appointing committees to carry on the section's assigned activities.

Central Ohio Chapter

Hears Talk on Sand Segregation

■ Sixty members at the November meeting heard W. D. Chadwick, Manley Sand Co., Rockton, Ill., discuss sand segregation.

Chadwick showed color movies which illustrated the behavior of dry sand under various applications of storage bin charging and discharging. He also summarized methods of bin design for minimum segregation and recommended various ways of storage. —*Joseph A. Riley*



SAND CONDITIONING TOPICS

PUBLISHED BY **ROYER**, MANUFACTURERS OF THE FOREMOST IN SAND CONDITIONING EQUIPMENT

ROYER OFFERS A PRACTICAL SOLUTION TO HOT SAND PROBLEMS

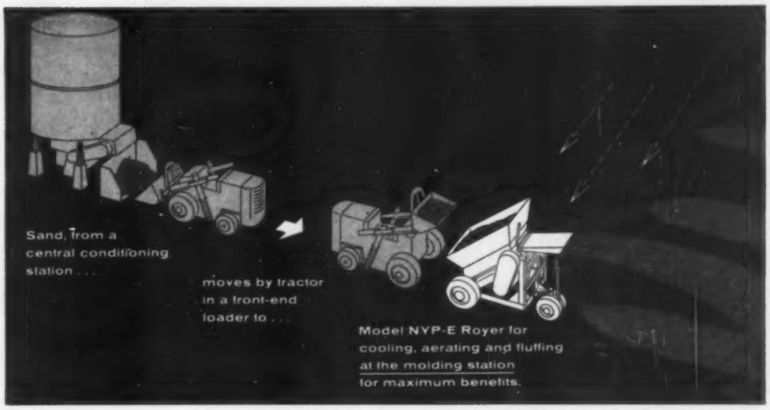
In today's foundry operation, time is probably the most costly element the superintendent must deal with. Sand used for today's casting must be conditioned and ready for use tomorrow. This frequently means sand conditioning at temperatures ranging up to 300° to 400°F.

These destructive high temperature operating conditions seem to plague every foundryman. Foundry equipment suppliers have offered many possible solutions—cooling towers, shake-out belt cooling, water cooling, rotary cooling, bin cooling, etc. But probably no manufacturer has offered more thorough cooling per dollar of invested capital than that obtained with Royer equipment.

All Royer Foundry Units employ the famous Royer Belt Combing Principle. In operation, a combing and mixing action takes place in the feed hopper. This breakdown of the hot sand mass releases the hot gases as the first step

in Royer Cooling. Further cooling of the individual sand particles takes place as the conditioned sand is discharged in an open stream. And finally, the sand heap, now open, light and fluffy, continues cooling at a very rapid rate.

There is a Royer Foundry Unit to solve every sand conditioning problem. Your inquiry is invited. We promise prompt reply—without obligation.



THERE IS A SAND CONDITIONING SYSTEM TO FIT YOUR BUDGET...

Here is a positive cost-cutting sand conditioning system that falls within the budget limitations of the small or medium semi-mechanized foundry. It delivers better sand without adding to time or manpower requirements, and without the expense of complete mechanization. It gains the advantages of fluffing after handling, as the final step at the molding station.

Teamed with front-end loader, this Royer NYP-E Portable moves from floor to floor in this grey iron foundry. What used to be caked, packed sand from mulling is now a cool, fluffy pile.

An integral part of this practical system is the Royer Model NYP-E Sand Separator and Blender. It can be moved swiftly from station to station, delivering cooled, aerated, fluffed, perfectly conditioned sand right where it's wanted. With this Royer you can really get all the advantages of central system sand control.

Your system is probably "different." There's still a versatile unit of the Royer "NY" Series to fit it . . . and improve it. As a stationary model, the "NY" will fit into a conveyor system, or can be installed to take the discharge of stiff sand directly from your muller. However you use it, the Royer vastly improves sand, saves time and money, improves yield and quality of castings —all at a fraction of a cent per ton of sand.

We'll be happy to have an experienced, foundry-wise Royer agent call to help you work out the system that's best for your operation. Or, if you prefer, we'll rush you a copy of Bulletin NY-54, giving further information about these units and how you will benefit from them. When you're convinced, *you* can call in your Royer agent and take the first step towards better sand with a Royer system.

ROYER FOUNDRY & MACHINE CO.

ROYER — 155 PRINGLE STREET, KINGSTON, PENNA.

☐ Tell your agent to call.
☐ Rush me a copy of Bulletin NY-54.

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Technical Paper Abstracts

Continued from page 47

age defects are hard to produce if melting is carried out carefully. It has often been misunderstood that there is little trouble in producing sound castings of tin bronze. This seems to be due to the fact that the shrinkage cavities in bronze castings are often so microscopically fine and dispersed that the porosities may not be noticeable. The purpose of this research is to clear up the mode of shrinkage defects and survey the effect of risers on soundness of tin bronze castings. By the radiographs, occurrence of porosities in castings were observed and effects of riser and cooling action of end portion of castings on the soundness of tin bronze castings were surveyed. At the same time some properties of castings were measured in relation to the defects. Brass and aluminium bronze castings were studied for comparison with the tin bronze.

In tin bronze, feeding of metal during solidification is essentially difficult because of its long freezing temperature range. In columnar crystal structured castings, shrinkage cavities are concentrated into the centerline portion and the sound end zone produced is longer than with equiaxial crystal growth. If pouring is made vertically, top gate is more desirable than bottom gate, and pouring should be done slowly. As to castings defects, brass and aluminium bronze show different behavior from tin bronze. Occurrence of shrinkage defects in those alloys resembles that of steel castings. . . . 6 pages in English.

Manufacture of Pig Irons for Nodular Graphite Cast Iron by Blast Furnace and Properties of the Irons by Isao Aoki.

Pig irons for nodular cast iron have been produced since 1953 by the blast furnace in Kamaishi Iron Works. Sometimes, inadequate pig irons for nodular cast iron were produced although contents of primary (C, Si, Mn, P, S) and secondary (Ti, As, Sn, etc.) elements were within specification of pig iron for nodular cast iron.

In order to inspect these accidents, the author investigated the practical producing conditions of these irons. And the following results were obtained:

The special elements such as Sn, As, Sb and Pb, etc., which came in pig iron from ore materials used in blast furnace had harmful influence on the formation of nodular graphite. The influence was emphasized by the presence of 0.05-0.1 per cent titanium.

Thus we were able to produce superior pig iron for nodular cast iron by using raw materials which contained a harmless amount of the above elements . . . 4 pages in English.

X-ray Motion Picture, Using an Image Intensifier, on the Flow on Metals in Shell Molds by Kanzaburo Shobayashi and Harumichi Okamoto.

Many researches have been made on the flow of metals in molds, using electric relays and X-rays. Many workers endeavoured to get some knowledge about the flow of metals from the flow of waxes, fusible alloys and mercury in glass molds. None of these researches, however, have illustrated perfectly the continuous flow or dynamic condition of actual high temperature molten metals.

The present authors have photographed the continuous flow of metals in molds, using an X-ray image intensifier, manufactured for medical studies by the X-ray department of our laboratory. A suitable film and camera for fluorescent image, cinematographs of the flow of metals was found and used to study the occurrence of blow holes and slag inclusions in molds. . . . 4 pages in English.

Gases in Cast Iron: Degassing Tests Under Vacuum by Sergio Gallo and Gino d'Alessandro.

Considering the developments of vacuum smelting and vacuum stream degassing of steels, the authors investigated the possibility of using this new technique in the field of cast irons.

They studied gray and malleable cast iron degassing at different vacuums ranging from ambient pressure to a pressure of 0.5 mm of Hg.

In gray cast irons oxygen favors the formation of shrink-holes while hydrogen and nitrogen, by stabilizing the carbides, cause the formation of hard spots and mottled areas.

In the cast irons intended for annealing, degassing accelerates remarkably the cementite decomposition process which starts at lower temperatures and is completed in shorter time periods.

For all types of cast iron, high percentages of gaseous elements cause interdendritic microporosities and blowholes in the castings. These flaws are eliminated by degassing. . . . 10 pages in French.

Graphitization of Ductile Cast Iron During Tempering by Dr. Premysl Rys.

A review of the processes which take place in ductile cast iron quenched during heating in the temperature range 22 C to 710 C is presented; the greatest attention being given to secondary graphitization produced with extraordinary rapidity in this material.

To determine the influence of structure on secondary graphitization, besides quenching, other types of treatment (austempering, normalising, deformation, and low-temperature preheating) were applied.

On tempering at low temperatures and with normal periods of time, tempering of ductile cast iron develops as in Si steels. The high Si content does not modify the temperature of the first temper phase to a great extent but it does considerably increase the temperature of the second and third phase of tempering. By these processes only the third temper phase has a direct influence on the formation of graphite nuclei.

Secondary graphitization develops rapidly when tempering at high temperatures. The production of graphite nuclei

has a decisive influence on its development, depending on the conditions of the matrix. This condition also affects the graphite growth rate and it may be modified by various ductile cast iron treatments prior to the graphitization anneal.

To avoid graphitization of iron and steel machine parts subjected to high-temperature conditions it is suggested that austempering, instead of toughening should be adopted as it favours graphitization less actively. . . . 11 pages in German.

Vacuum Casting of Gray Iron by Otto Necas and Robert Kamensky.

The process was done, on the laboratory scale, placing mold in a casing, the inlet of which was sealed by a sheet of aluminium and the air from which was pumped out, before the casting. After the pouring basin had been filled, the sheet was melted and the stream of iron was subjected to vacuum.

The pressure in the casing was: 4.9 mm. Hg. before the casting, 6.-25 mm. Hg. during the casting and 14-30 mm. Hg. after. The chemical constitution of the vacuum treated cast iron remained unchanged, except sulphur was reduced in most cases by about 10 per cent. The content of gases was reduced considerably: hydrogen by 43 per cent, oxygen by 21 per cent and nitrogen by 12 per cent.

With vacuum casting the tensile strength of gray cast iron decreases about 20 per cent and its hardness about 13 per cent. The unfavorable influence of the vacuum casting upon the mechanical properties of gray cast iron is due to the change of its microstructure. The vacuum treated castings have more ferrite and under-cooled graphite than the usual castings. Fracture cracks in vacuum treated castings run mainly through areas with undercooled graphite and occur even with a low stress. . . . 10 pages in German.

The Mechanism of the Production of Peripheral Blowholes in Cast Steel by Josef Pribyl and Ondrej Starosta.

For the last twenty years steel plants in Czechoslovakia have been trying to eliminate peripheral blowholes but did not obtain great success till some years ago. The reason for the continuous unreliability is that no difference between peripheral blowholes and "effervescence blisters" had been made.

Opinions held heretofore on peripheral blowholes may be classified into four groups. The most correct estimates that the carbon monoxide resulting from the carbon reaction provides the impulse for the production of peripheral blowholes.

The kinetics for the production of peripheral blowholes is characterized by four stages: 1. The decomposition of the water vapor from the mold. 2. Oxidation of the molten iron on the surface of the casting. 3. The carbon reaction and inoculation of the peripheral blowholes by the CO produced. 4. Diffusion of the gases (hydrogen) in the violent small CO blisters and their growth to final size.

The different thickness of the layer of blowholes depends on the FeO concentration and the different size of the blowholes on the dissolved gas content (hydrogen) in the steel.

The protective measures against peripheral blowholes are based on the prevention of steel from contact with any form of moisture after "boiling", in not prolonging the charge after "boiling", in a complete deoxidation, in avoiding any useless transfer of the steel (in this case the subsequent deoxidation of the steel in small ladles is necessary) and in avoiding depression in the runner gate system during pouring. . . . 8 pages in German.

Statistical Investigations of the Influence of the Method of Casting Test Pieces Separately Cast in Sand Molds for Copper Alloys by Zbigniew Gorny and Aleksander Fijal.

The role and significance of test pieces separately cast is limited essentially to the evaluation of the liquid metal from which the castings are at the same time made. Since the casting of test pieces may be defective in the same way as in normal casting, the problem of a proper method of casting of test pieces becomes important. The work was undertaken in order to determine the best way of casting test pieces separately cast into sand molds on the basis of comparative statistical studies which involved the method of casting test pieces according to American, English, French, Czechoslovakian, and Polish standards.

The investigations were carried out on the following alloys: CuSn5Zn5Pb5, CuAl10Fe3Mn2, CuSi3Zn3Mn1, Cu58-Al2Fe2Mn1Zn, Cu60Pb2Zn and Cu80-Si4Zn. . . . 14 pages in German.

Ferro Alloys and Inoculants for the Production of High Strength Gray Cast Iron by Howard H. Wilder.

The introduction of this paper consists of a historical background to the field of gray iron foundry operations. A description of the products, chemistry involved, and microstructures encountered are reviewed.

Typical examples of American inoculation practice for production of 30,000, 35,000 and 45,000 psi tensile strength irons are given along with analysis and metal charge mixtures. The production of high strength gray cast irons by using inoculants and alloying materials for 30,000 and 40,000 psi tensile irons are also presented.

Conditions under which graphitizing and stabilizing type inoculants can be used are shown in the paper.

Alloys for achievement of specific results are summarized in a table for ready reference. Typical high strength gray cast irons that are representative of American operations are shown with strengths before and after additions.

Effects of minor elements present in inoculants and the relationship they play are outlined by the author. . . . 5 pages in English. ■ ■ ■

afs chapter meetings

JANUARY

Birmingham District . . Jan. 8 . . Thomas Jefferson Hotel, Birmingham, Ala. . . S. D. Moxley, American Cast Iron Pipe Co., *"European Foundries."*

British Columbia . . Jan. 15 . . Leon's, Vancouver, B. C. . . H. Heath, Aluminum Co. of America, *"Casting Aluminum in Permanent Molds."*

Canton District . . Jan. 7 . . Elks Club, Barberton, Ohio . . *Panel Discussion.*

Central Illinois . . Jan. 4 . . Vonachen's Junction, Peoria, Ill. . . W. C. Capehart, Monsanto Chemical Co., *"New Foundry Resins & Application Techniques for Shell Molds & Shell Cores."*

Central Indiana . . Jan. 4 . . Turner's Athenaeum, Indianapolis . . *Panel Chairman*: W. Ballantine, Haynes Stellite Co., *Panel Discussion, "Start 1960 Whipping Poor Quality."*

Central Michigan . . Jan. 20 . . Hart Hotel, Battle Creek, Mich. . . T. W. Curry, Lynchburg Foundry Co., *"Quality Control."*

Central New York . . Jan. 8 . . Drumlin's, Syracuse, N. Y.

Central Ohio . . Jan. 23 . . Lincoln Lodge, Columbus, Ohio . . *Winter Party.*

Chesapeake . . Jan. 9 . . American Legion Hall, Parkville, Md. . . *"Oyster Roast."* . . **Jan. 29 . .** Engineers' Club, Baltimore, Md. . . Z. Madacey, Beardsley & Piper Div., Pettibone Mulliken Corp., *"Coremaking."*

Chicago . . Jan. 4 . . Chicago Bar Association, Chicago . . S. C. Massari, AFS, *"Marketing Your Product." Past Presidents' Night.*

Cincinnati District . . Jan. 11 . . Alms Hotel, Cincinnati . . *Ferrous Group*: W. R. Jaeschke, Whiting Corp., *"Fundamentals of Cupola Operations"; Non-Ferrous Group*: T. E. Kramer, American Alloys Corp., *"Producing Quality Aluminum Castings."*

Connecticut . . Jan. 26 . . Waverly Inn, Cheshire, Conn.

Corn Belt . . Jan. 15 . . Marchio Restaurant, Omaha, Neb.

Detroit . . Jan. 7 . . Wolverine Hotel, Detroit . . E. E. Braun, Central Foundry Div., GMC.

Eastern Canada . . Jan. 8 . . Mt. Royal Hotel, Montreal, Que. . . *Round Table Discussion Groups—Non-Ferrous*: R. Woods, Montreal Bronze, Ltd.; *Steel*: R. Thompson, Dominion Engineering Works; *Iron*: L. Fortin, Canada Iron Foundries Ltd.

Eastern New York . . Jan. 19 . . Panetta's Restaurant, Menands, N. Y.

Metropolitan . . Jan. 4 . . Military Park Hotel, Newark, N.J. . . *Non-Ferrous Group*: G. Horner, Fischer Casting Co.; *Ferrous Group*: C. F. Menzer, Superior Bearing Bronze Co.; *"Coremaking for Ferrous & Non-Ferrous Foundry."*

Michiana . . Jan. 2 . . Normandy Club, Mishawaka, Ind. . . L. B. Welty, *"Quality Control in a Gray Iron Foundry."*

Mid-South . . Jan. 8 . . Claridge Hotel, Memphis, Tenn.

Mo-Kan . . Jan. 21 . . Fairfax Airport, Kansas City, Kans. . . R. Cochran, R. Lavin & Sons, *"Non-Ferrous."*

New England . . Jan. 13 . . University Club, Boston.

Northeastern Ohio . . Jan. 14 . . Tudor Arms Hotel, Cleveland . . *Ferrous Group*: E. J. Passman, Frederic B. Stevens, Inc., *"Use & Abuse of Core & Mold Washes"; Non-Ferrous Group*: W. Bonsack, Aluminum & Magnesium, Inc. *"Aluminum Melting Practice for Permanent Mold & Die Castings"; Pattern Group*: C. E. Goodman, Cleveland Foundry, Ford Motor Co., *"Engineering Pattern Equipment for Automation." Joint Meeting with Society of Die Casting Engineers.*

Northern California . . Jan. 11 . . Red Rooster Restaurant, Oakland, Calif. . . H. Heath, Aluminum Co. of America, *"Casting Aluminum in Permanent Molds."*

Northern Illinois & Southern Wisconsin . . Jan. 12 . . Beloit Country Club, Beloit, Wis. . . T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Corp.

Northwestern Pennsylvania . . Jan. 25 . . Amity Inn, Erie, Pa.

Ontario . . Jan. 22 . . Royal Connaught Hotel, Hamilton, Ont. . . *Past Chairmen's Night.*

Oregon . . Jan. 13 . . Heathman Hotel, Portland, Ore. . . H. Heath, Aluminum Co. of America, *"Casting Aluminum in Permanent Molds."*

Philadelphia . . Jan. 8 . . Engineers' Club, Philadelphia . . E. F. Pierce, Lynchburg Foundry Co., *"Work Simplification."*

Piedmont . . Jan. 8 . . Virginian Hotel, Lynchburg, Va. . . D. E. Krause, Gray Iron Research Institute, *"Cupola Operations & Foundry Coke."*

Pittsburgh . . Jan. 18 . . Webster Hall Hotel, Pittsburgh, Pa. . . F. H. Dettore, G. E. Smith, Inc., *"Cold Curing Cores."*

Quad City . . Jan. 18 . . LeClaire Hotel, Moline, Ill. . . W. M. Ball, Jr., R. Lavin & Sons, Inc., *"Human Engineering."*

Saginaw Valley . . Jan. 7 . . Fischer's Hotel, Frankenmuth, Mich. . . *Panel Discussion, "Refractory Practice in Saginaw Valley Foundries."*

St. Louis District . . Jan. 14 . . Edmond's Restaurant, St. Louis . . F. M. Scaggs, Oklahoma Steel Castings Co., *"CO_2 Process."*

Southern California . . Jan. 8 . . H. Heath, Aluminum Co. of America, *"Casting Aluminum in Permanent Molds."*

Tennessee . . Jan. 29 . . Wimberly Inn, Chattanooga, Tenn. . . D. E. Krause, Gray Iron Research Institute, *"Chill Test & Metallurgy of Gray Iron."*

Texas . . Jan. 15 . . Ben Milam Hotel, Houston, Texas.

Texas, San Antonio Section . . Jan. 18 . . San Antonio Machine & Supply Co., San Antonio, Texas . . *"Gating & Risering."*

Toledo . . Jan. 6 . . Heatherdowns Country Club, Toledo, Ohio.

Tri-State . . Jan. 8 . . Alvin Hotel, Tulsa, Okla.

Twin City . . Jan. 12 . . Jax Restaurant, Minneapolis . . W. D. Chadwick, Manley Sand Co., *"Sand Segregation."*

Utah . . Jan. 18 . . Salt Lake City . . D. Matter, Ohio Ferro Alloys Corp., *"Metallurgy of Cast Iron."*

Washington . . Jan. 14 . . Engineers' Club, Seattle . . H. Heath, Aluminum Co. of America, *"Casting Aluminum in Permanent Molds."*

Western Michigan . . Jan. 4 . . Bill Stern's, Muskegon, Mich. . . G. DiSylvestro, American Colloid Co., *"Veining & Penetration."*

Western New York . . Jan. 8 . . Sheraton Hotel, Buffalo, N.Y. . . C. A. Sanders, American Colloid Co., *"Comparison of Molding Methods."*

Wisconsin . . Jan. 8 . . Schroeder Hotel, Milwaukee . . S. C. Massari, AFS, *"Marketing Your Product."*

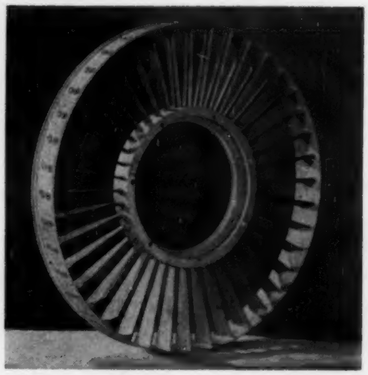
FEBRUARY

Central Indiana . . Feb. 1 . . Athenaeum, Indianapolis . . A. James, Haynes Stellite Co., *"Nonproductive Labor Efficiency Measurement."*

Metropolitan . . Feb. 1 . . Military Park Hotel, Newark, N. J. . . J. A. Mueller, Carborundum Co., *"Grinding, Cleaning & Finishing of Castings."*

here's . . . . . . how

. . . **Haynes Stellite Co.,** New York, mass produces de-icer vanes for an air duct system. Vanes are investment cast with several transverse

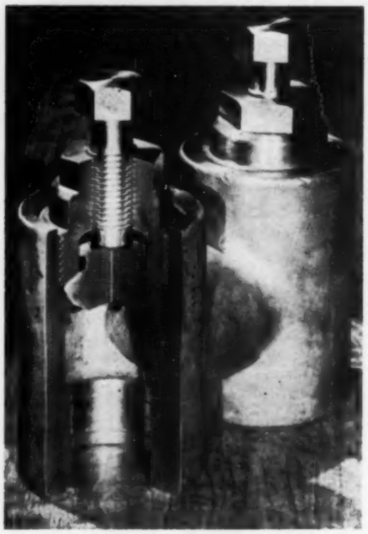


channels that lead back to the trailing edge. Heated air at 600 F keeps ice from forming around the first stage of a compressor.

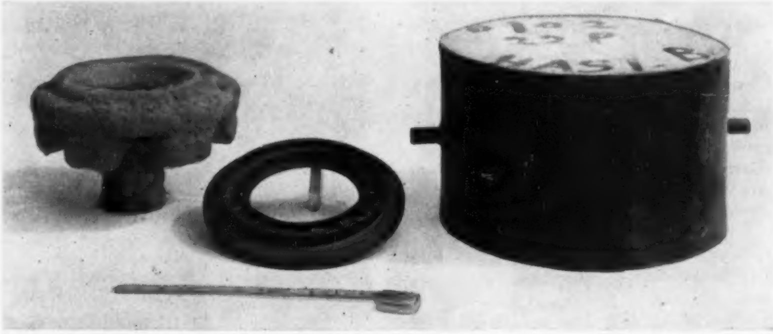
. . . **cast stainless steel impellers** have operated for nine years in corrosion and erosion environment of

chemical pumps used in paper pulp processing by Kingsport Div., The Mead Corp., Kingsport, Tenn. The cast stainless alloy contains 19% Cr, 10% Ni, 0.08% max C, and 2.0-3.0% Mo. It has exceptional corrosion resistance and strength. Pictured here after 9 years service, the impellers evidence no sign of attack or wear.

. . . **a cast stainless steel header** is meeting punishing demands of corrosive environment at the high octane gasoline plant of Standard Oil Co. of California, El Segundo, Calif. Alloy type CF-8 (Alloy Casting Insti-



tute designation), containing 18-21 per cent Cr, 8-11 per cent Ni and a maximum of 0.08 per cent C, passes x-ray inspection and cold kerosene pressure test at 3000 psi.



. . . **Ferro Cast, Div. of J. B. Rea Co.,** Santa Monica, Calif., uses new ceramic shell investment casting technique to save time and money in making this turbopump nozzle. Process permits larger investment castings and better precision than heretofore possible.

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11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215	227
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10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214	226
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Continued on page 126

Circle No. 167, Page 123

for the asking

Continued from page 124

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Mold cavity coatings . . . colloidal dispersions said to result in more uniformly sound castings having smoother surface finishes. Send bulletin, Vol 4, No. 1. Acheson Colloids Co.
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■ The following reprints of feature articles which apeared in MODERN CASTINGS are available to you free of charge. Use the Literature Request Card.

Enamelware castings . . . requiring techniques peculiar to the vitreous enameling process discussed in free MODERN CASTINGS reprint including emphasis on use of synthetic or semi-synthetic sands, metallurgy and annealing practices. American Foundrymen's Society.
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Quality control . . . in a brass foundry discussed in article reprinted from MODERN CASTINGS. American Foundrymen's Society.
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Steel castings . . . mechanical properties and processing techniques to effect high strength covered in reprint from 1959 AFS TRANSACTIONS. American Foundrymen's Society.
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Missile and aircraft . . . quality castings are produced in this foundry. Read about it in free reprint from MODERN CASTINGS. American Foundrymen's Society.
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Steel Casting Design . . . soundslide motion picture, color, 16 mm, 25 min., free loan. Steel Founders' Society of America.
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foundry trade news

CAST BRONZE BEARING INSTITUTE . . . product group of Non-Ferrous Founders' Society, elected William H. Grossman, Randall Graphite Bearings, Inc., Lima, Ohio, as president. Other officers: vice-president, Carter N. Padden, Jr., Moccasin Bushing Co., Chattanooga, Tenn.; secretary-treasurer, A. G. Eberle, Renewal Service, Inc., Philadelphia. Three-year directors—A. G. Eberle; P. J. Bauman, National Bearing Div., American Brake Shoe Co., Pittsburgh, Pa.; two-year terms—C. N. Padden, Jr., C. Beckett, Beckett Bronze Co., Muncie, Ind.; one-year terms—W. H. Crossman, M. E. Nevins, Wisconsin Centrifugal Foundry Inc., Waukesha, Wis.; G. F. Langford, Superior Kendrick Bearings, Inc., Detroit.

DUCTILE IRON SOCIETY . . . at its fall meeting in Detroit heard president R. S. Thompson stress the importance of quality control, cost control and the value of cooperative research and study of operating and production problems. A substantial increase in ductile iron was predicted for 1960. Vice-president William Beatty reported on the summer seminar and executive secretary James H. Lansing, lead a discussion of quality control methods.

STEEL FOUNDERS' SOCIETY . . . held its 14th annual technical and operating conference Nov. 9-11 in Cleveland with more than 500 attending. Committee chairman Dale L. Hall, Oklahoma Steel Castings Co., Tulsa, Okla., was general chairman. Program developments and arrangements were directed by C. W. Briggs, technical and research director.

Dr. A. H. Sully

Dr. Arthur H. Sully, director, British Steel Castings Research Association, Sheffield, England, presented the annual exchange lecture, "Dust Control and Noise Abatement." Sessions on the first day were devoted to steel production and treatment, the exchange lecture, and operations in steel foundry finishing departments including oxygen-gasoline cutting, arc-air finishing methods, use of abrasive cut-off machines, abrasive for blasting and foundry data handling by use of IBM equipment. On the second day discussions were held on molding methods and a review of the fundamentals of steel foundry sands were held on the third day.

INVESTMENT CASTING INSTITUTE . . . Investment Casting Institute at its 7th annual meeting held Nov. 3 in Chicago, elected John H. Morison as president. Other officers: vice-president, management division, R. E. Gray, Gray-Syracuse, Inc.; vice-president, technical division, R. F. Waindle, WaiMet Alloys Co.; treasurer, L. R. Schwedes, Lawrence Laboratory. Directors, 1-year term: immediate past president R. R. Miller, Precision Metalsmiths, Inc.; P. J. Nilsen, Electronicast Div., Nilsen Mfg. Co. and T. N. Thys, Precision Founders, Inc.; directors, 2-year terms: J. H. Cadieux, Casting Engineers and W. A. Dubovick, Engineered Precision Casting Co.

L. E. Carr, Precision Metalsmiths, Inc., and R. H. Herrmann, *Foundry* magazine, were presented with I.C.I.'s Whale award for distinguished service to the investment casting industry. Carr is chairman of the publications committee and Hermann served as editor of the institute's new book "How to Design and Buy Investment Castings."

Newly elected officers and directors of Investment Casting Institute. Seated, left to right: **R. E. Gray**, Gray-Syracuse, Inc., vice-president, management section; **J. H. Morison**, Hitchiner Mfg. Co., I.C.I. president; **R. F. Waindle**, WaiMet Alloys Co., vice-president, technical; **L. R. Schwedes**, Lawrence Laboratory, I.C.I. treasurer. Standing: **W. A. Dubovick**, Engineered Precision Casting Co.; **J. H. Cadieux**, Casting Engineers, Inc.; **R. R. Miller**, Precision Metalsmiths, Inc.; **P. J. Nilsen**, Electronicast Div., Nilsen Mfg. Co. Those standing are directors. R. R. Miller is the society's immediate past president.

NON-FERROUS FOUNDERS' SOCIETY . . . at its 1959 annual meeting elected M. E. Nevins, Wisconsin Centrifugal Foundry, Inc., Waukesha, Wis., as president. Other officers: 1st vice-president, E. G. Brummund, Jr., Brummund Foundry Co., Chicago; 2nd vice-president, D. A. Mitchell, Progressive Brass Mfg. Co., Tulsa, Okla.; H. F. Scobie continues as secretary treasurer. National directors elected for three-year terms are: R. E. Dickison, Brass Foundry Co., Peoria, Ill.; L. J. Andres, Lawran Foundry Co., Milwaukee; W. O. Larson, Grafton Foundry Co., Grafton, Ohio; N. W. Meloon, Meloon Bronze Foundry, Syracuse, N. Y.; J. J. Markovich, Northern Cast Alloy, Inc., Van Dyke, Mich. Robert Langsenkamp, Langsenkamp-Wheeler Brass Works, Inc., Indianapolis, was re-elected as a director at large.

M. E. Nevins

W. A. Gluntz, left, receives N.F.F.S. distinguished service award from **Robert Langsenkamp**, chairman of the awards committee.

Continued on page 131

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41 **Foundry Supply Houses,** keyed to all the Products they supply.
133 **pages** of Catalog Advertising prepared specially for the Buyers Directory.
42 **pages** of data on the 12 major Foundry Associations and their services.

Every Foundry in the U. S. and Canada will receive at least one copy gratis. World-wide distribution has been arranged. The 2d edition will be published in fall of 1961.

List Price to ALL **$10.00** (8-1/2 x 11 Case bound over 350 pages)

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foundry trade news

Continued from page 129

Wm. A. Gluntz, Gluntz Brass & Aluminum Foundry Co., Cleveland, who has served as a national director, president 1947-48 and currently a director-at-large, was presented with the society's first distinguished service award.

Charles Mease, Lebanon Steel Foundry Co., Lebanon, Pa., and **C. R. Wolf,** New Jersey Silica Sand Co., Millville, N. J., shown in new holly house located on site of New Jersey Silica Sand Co. Over 500 foundrymen attended the dedication on Nov. 4. The stainless steel plaque was made by Lebanon Steel Foundry.

Conveyor Belt Service, Inc. of Ohio . . . Cleveland, has been formed for repair and reconditioning of conveyor belting. Operations are expected to start in January. Central States Industrial Supply Co., Cleveland, will be exclusive sales representatives in that area.

Egloff & Graper, Inc. . . . Los Angeles, has been named as southern California representatives of Thermal Research & Engineering Corp., Conshohocken, Pa., handling indirect heat exchangers, inert gas generators and high heat release combustion equipment.

Johnston & Funk Metallurgical Corp. . . . Wooster, Ohio, has moved its headquarters and plant to Huntsville, Ala. The relocation of manufacturing facilities coincides with a change in corporate relationship between Johnston & Funk and Mallory-Sharon Metals Corp., Niles, Mich. Johnston & Funk was formerly a wholly-owned subsidiary of Mallory-Sharon. Now Johnston & Funk is owned by Mallory-Sharon and P. R. Mallory Co., Indianapolis. A midwest sales office will be maintained at Wooster, Ohio.

Alloy Steel Castings Co. . . . Southampton, Pa., is adding 12,000 sq ft to its present facilities. An additional 8000 sq ft will be added early in 1960 for precision casting facilities.

New Jersey Zinc Co. . . . New York, has announced a cash awards competition for the best examples of light-weight, thin-wall zinc die castings used in product design. Awards will be 1st place $200; 2d, $100; 3d, $50.

Allis-Chalmers Mfg. Co. . . . reports a 34 per cent increase in third quarter sales in 1959 as compared to 1958 and a 103 per cent earnings increase for the same period. Third quarter sales in 1959 amounted to $166,622,722 and earnings after preferred stock dividend requirements, $10,034,614. For the third quarter in 1958 sales were $124,242,243 and earnings amounted to $4,929,106. On a per share basis, the profit in the two comparable quarters amounted to $1.12 and 60 cents.

A. P. Green Fire Brick Co. . . . Mexico, Mo., has acquired Dixie Fire Brick Co., Birmingham, Ala. Jack Q. Lewis and John Lewis, Jr., sons of founder, remain as officers to manage the plant.

Standard Refractories Ltd. . . . Recently formed Canadian firm has moved its office and warehouse to Foot of Wellington St., Hamilton, Ont. Additional equipment has been added to its manufacturing facilities.

Harbison-Carborundum Corp. . . . has been formed by Harbison-Walker Refractories Co., Pittsburgh, Pa., and Carborundum Co., Niagara Falls, N. Y., for the engineering manufacture and sales of fused refractories.

pouring off the heat

work smarter . . . not harder

■ It's always interesting to learn how other foundries are not wanting their employees to do a better job. Certainly Jack Irish's article "Work Smarter . . . Not Harder" is an eye opener. We at Mainland do not have such a program but I believe such a program would pay large dividends.

In my experience workers in most plants seem to need something to give them a greater interest in both their own job and in the company for which they work. A program in which the employee can take a part of and receive benefits for extra effort or thought is bound to succeed.

Such a plan must be well thought out, introduced slowly and explained fully to the employees, so that no misunderstanding can develop which could jeopardize the program. Once such a program is started and fails, it becomes much more difficult to start over again.

In all probability a new department would have to be created in smaller plants such as ours with a payroll of 125 persons. The head of this department should be a man fully qualified for the job to be undertaken.

I fully believe such a program undertaken by any forward thinking plant would find benefits both in increased profits and better employee relations and usually they both go together.

H. Heaton
Mainland Foundry
Vancouver, B. C.

comments on workmen's compensation

■ May I congratulate Mr. J. A. Bloomquist for having the courage to write on a legal subject which to a lawyer is simple and fundamental but which sometimes is made the subject of controversy. Actually the argument, if any there be, should be with the legislators who make the laws, not with the man who explains them as they actually do exist.

Each state has its own Workmen's Compensation laws. It is quite a job to find the points of similarity and cover them all in plain understandable English. It would appear that Mr. Bloomquist has attempted just this and my hat's off to him.

Kenyon D. Love
Executive Vice Pres. & Sec.
The Colonial Foundry Co.
Louisville, Ohio

■ The MODERN CASTINGS article written by J. A. Bloomquist and entitled "Do

Continued on page 134

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pouring off the heat

Continued from page 132

You Understand Workmen's Compensation" provides an excellent background on the subject. In case any of your readers are interested in pursuing the subject a little deeper into the legal aspects I would like to call their attention to the following paper: "The Future of Workmen's Compensation" presented by the undersigned before the American Bar Association, Aug. 26, 1959, Miami Beach, Fla.

This paper covers such subjects as: expanding areas of coverage; definition of "accident"; occupational disease coverage; and cooperation between industry and labor. Perhaps you will find some answers to your foundry problems.

Noel S. Symons
Vaughan, Brown, Kelly, Turner & Symons
Buffalo, N. Y.

more on depreciation

■ Mr. Allan Slichter's Comments regarding replacement costs are very well taken. If it were not for space limitations and the fact that the article was written primarily from a tax standpoint it would have been remiss of me to ignore the problem of replacement costs.

Your annoyance with paying "income tax on earnings that are actually fictitious" is quite understandable, but tax law is not always as equitable as it might be. Despite the fact that you cannot deduct depreciation based on replacement cost for tax purposes there is nothing to prevent one from showing this item as an expense on the financial statements used for managerial control. Many firms have adopted this practice and, in general, believe that it gives them a depreciation picture that is closer to economic reality than by using the traditional method.

Even with the use of the replacement method wide differences of opinion exist as to its efficacy. As an illustration—who is to say what the replacement cost will be ten years from now for a machine that I bought today? As you can well imagine the whole area of depreciation is fraught with uncertainties. The trick is to reduce them to the lowest possible level.

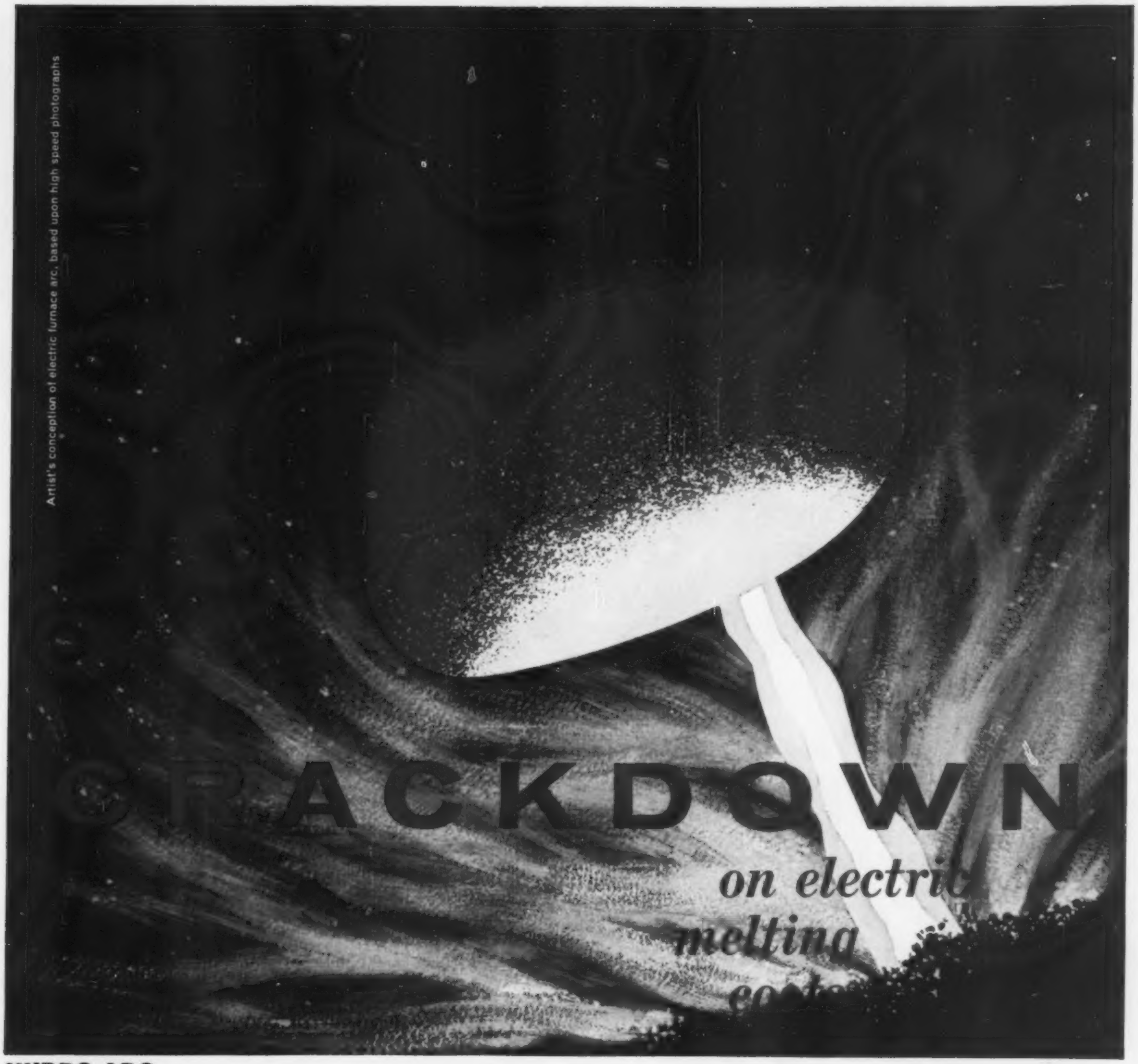
Irving Elbaum
Certified Public Accountant
Los Angeles

thank you

■ Our heartiest congratulations on your last issue. You and your staff are doing an exceptionally fine job which is reflected in the excellent articles, format and presentation.

We find the articles of such interest and help that we remove them from the magazine for our library reference folders and use them in foundry training.

R. B. McKinley
McKinley Metal, Inc.
Fort Worth, Texas



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Circle No. 181, Page 123

classified advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words, ($9.00) minimum, prepaid.
Positions Wanted . . 10c per word, 30 words ($3.00) minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 additional words.
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STEEL FOUNDRY SUPERINTENDENT experienced in all phases of foundry practice and cleaning room operation to take complete charge of a modern, progressive, medium-sized steel foundry in the Southwest area. Reply with complete details, including salary expected, references and recent photograph. **Box A-101, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SUPERINTENDENT for complete charge of small, jobbing type, gray-iron foundry. New, modern building and equipment. Must have some knowledge and experience in all phases of foundry operation including production, cupola operation, sand control, metallurgy, etc. Reply should include age, resume of experience, education, and salary requirements. Photo if possible. **CENTRAL MACHINE WORKS CO., 1234 Central Ave. N.E., Minneapolis 13, Minnesota.**

GENERAL CLEANING ROOM FOREMAN

Desire man 30-40 years of age with necessary drive and skill to organize department. Must have knowledge of the various cleaning room processes including welding, heat treating, arcair and materials handling methods. Reply giving age, resume of experience, personal background and salary requirements. All replies held in confidence. Reply to: **WORKS MANAGER**

MINNEAPOLIS ELECTRIC STEEL CASTINGS COMPANY
3800 N. E. FIFTH STREET
MINNEAPOLIS 21, MINNESOTA

PLANT ENGINEERS

Experienced on layout of all types of foundry equipment, material handling and material flows. Send complete details on work history, education and family status. Include recent photograph. All replies confidential. **Box F-140, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

WANTED

Graduate engineer or metallurgist for iron casting sales and service. Must be under 34 years. Excellent opportunity with growing organization in Wisconsin. **Box A-103, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

One of the largest producers of patented foundry products will need two sales and service engineers to locate in the Ohio and Philadelphia areas. These men must have lived and worked in the respective areas and belong to the local foundry Society. We are interested in men who have foundry background in mold, core making and sand control; and with technical sales and service experience, between 30 and 40 years of age. Please send resume and salary requirements. All replies held in confidence. **BOX A-107, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SENIOR INDUSTRIAL ENGINEER

Top-Notch man wanted with broad foundry knowledge. Must be capable to set up and administer industrial and process engineering department. ME or IE degree required. For consideration submit complete details on experience, education and personal data. Include recent photo. All replies held in confidence. **Box K-106, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

PHYSICAL ANAYLST

B.S. in Metallurgical Engineering preferred. Will accept related degree with lab experience in physical and pyrometry testing of ferrous metals. Good starting salary, excellent growth opportunity in new lab of leading Northwest Pennsylvania manufacturer in heavy industry. Write stating full qualifications and salary requirements. **Box A-102, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SUPERINTENDENT

Wanted superintendent for small non-ferrous sand castings foundry in Rockford, Ill., area. Must have complete knowledge and experience in melting, gating and rigging of patterns. Sand control and sundry practices of a sand castings non-ferrous foundry. Give full qualifications and references. **Box F-156, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SUPERVISOR desires foreign employment. Background — steel, gray iron and malleable. Age 35, married and free to travel. Presently employed. **Box A-100, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRYMAN — 26 years job and production foundry experience. All departments. Helper to top management. Gray iron, alloy iron, non-ferrous. Some college. College teaching. 18 years supervision. Age 45. Resume on request. **Box A-105, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SUPERINTENDENT. Twenty years broad experience in ferrous and non-ferrous jobbing and production work. Presently employed in Western Canada and wish to relocate. **Box A-104, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY EXECUTIVE — foundryman desires position in iron or ductile production foundry. 48 years old. College degree and 12 years as foundry and plant superintendent. Consider consulting. **Box A-108, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

dietrich's corner

by h. f. dietrich

Our Manpower Bottleneck

Everywhere we hear anguished cries about the impending shortage of scientists. After a plant visitation to a mechanized foundry recently, I began to wonder whether the bottleneck in manpower isn't going to be at the other end of the labor scale.

The industrial revolution has been carried to the point where we use only a man's hands. The primary reason for man's superiority to other animals, his ability to think, is being allowed to stagnate at the labor level of mechanized production. Instead of the man running the machine, the machine now runs the man. It times his movements, regulates his distance of travel, and even controls his biological functions.

As an example, the duties of one worker in this mechanized foundry consisted of placing one-half of a shell mold on a conveyor. He could see neither the point where the shell originated nor its destination after he placed it on the conveyor car. The shell was blown of urea resin bound sand. It went through a baking cycle on a covered turn table. Mechanical fingers lifted the hot, foul smelling shell and handed it to the man who placed it on a jig indexed car. It takes an unusual I.Q. to really enjoy and take pride in such a job, especially on the swing shift. As our working force becomes better educated, it will become increasingly harder to find men who will allow a machine to hand them shells to place on a conveyor.

Another job in this foundry must have been called, "Left Side Casting Raiser." The man at this work station had the important duty of placing a prybar under the hot casting as it moved slowly from the smoke hood. By prying against the drag flask he could raise the casting high enough, and free it from the mold sand sufficiently to insert a hook which was attached to a traveling beefrail. Now understand, this man was not responsible for *both* sides of the casting. It was the duty of another man to see that the other beefrail hook was placed in position. After both hooks were placed, a track designed by an industrial engineer raised the casting from the drag and moved it over a vibrating shakeout. The man placing the hook neither saw nor cared what happened to the casting after he pried it out of the sand.

Man is a vain creature. To be happy, he must brag to his fellow man about his accomplishments. From the Pharaohs of ancient Egypt to contemporary writers of poem and song, he has found satisfaction in bragging about his work. But who can brag about being Left Side Casting Raiser? Homer would have a rough time making anything out of that. Longfellow couldn't do a thing with the scenery. The man didn't require the physique of the Village Blacksmith, so you couldn't approach it from that angle. The Left Side Casting Raiser must go through life unheralded. You can't do much with it in eulogy either.

A conveyor system regulates the pace in a mechanized foundry. Whether this is fast or slow, it is fatiguing and frustrating to the worker—provided he has enough space between his ears to wear anything larger than a number five hat. The energy of man does not flow at a constant rate. With the machine setting the pace, he must slow down when he feels like moving, and speed up when he feels least inclined to do so. Such a regime would produce neurosis in an orangutan.

With high school education practically compulsory for all except the mentally retarded, the education level of our working force is constantly climbing. We can no longer depend upon immigration to fill our low level labor needs. So where do we find the Left Side Casting Raiser? I suggest that the bottleneck in our labor force will not be at a scientific level. In a few years, the man capable of being bossed by a machine will be hard to find.

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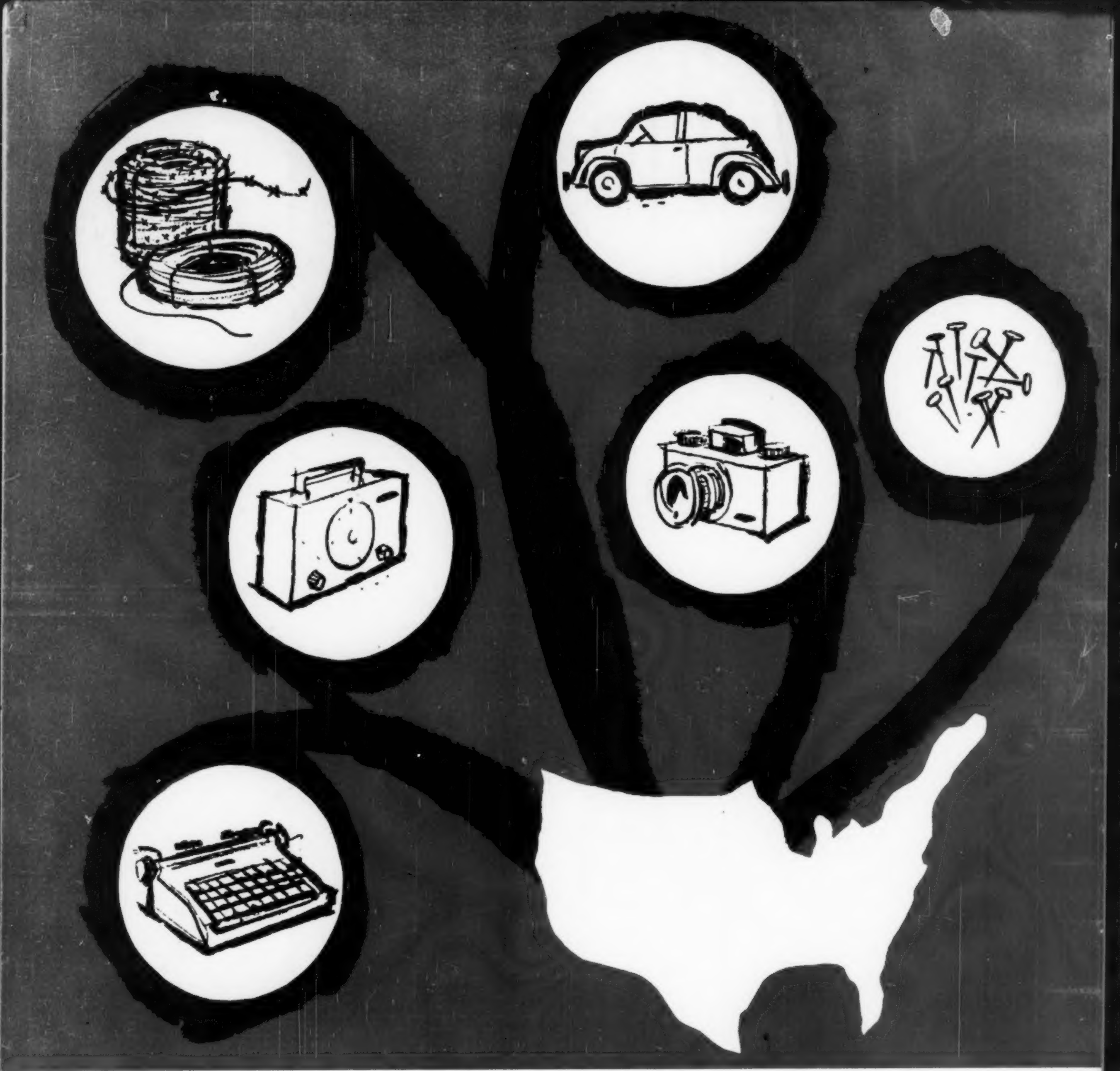

SIX DIFFERENT WAYS TO LOSE A JOB

The man in the picture at left could be your neighbor . . . or could be you. Shown above him are a few of the many imported articles he and other Americans have been buying at prices substantially lower than those of domestic products in steadily rising quantities. Each sale of an imported item means a lost sale to a domestic producer: each lost sale inevitably must be reflected in lower production by domestic producers which in turn must mean fewer jobs for American workers.

The problem of imports is one the ferro-alloys industry has had to face for several years, and the reason for our concern, while based naturally enough on our lost sales, is that this trend must ultimately have a serious effect on the jobs of every American. Further, this trend could all too easily affect the strength of American industry on which our entire economy is based.

Perhaps the import problem has not yet made itself felt in your industry. It will.

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